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(54) **APPLICATION SERVER PROVISIONING BY DISK IMAGE INHERITANCE**

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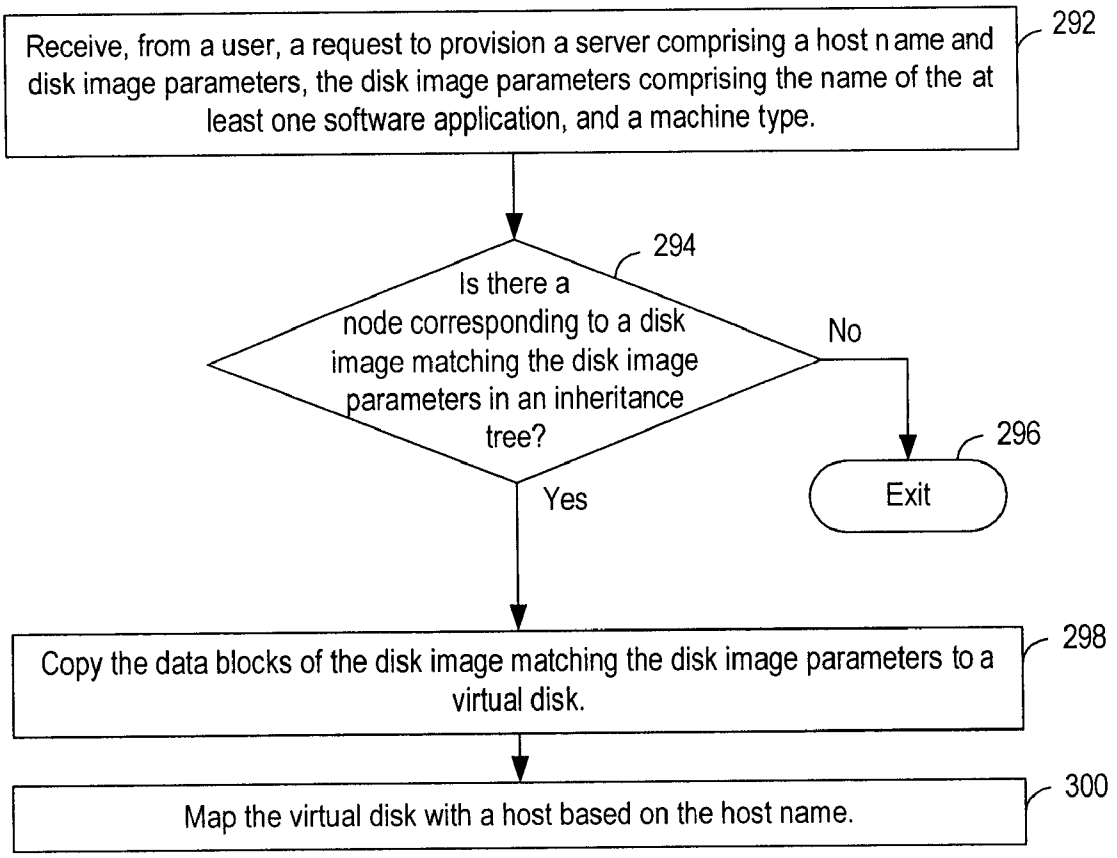
(57) **ABSTRACT**

A disk image is generated, stored in at least one persistent storage device, comprises at least one software application, and is a root disk image. An inheritance tree comprising a root node associated with the root disk image is created. A new disk image of a disk is generated based on a previously generated disk image associated with a node of the inheritance tree. The new disk image is stored in at least one persistent storage device, and comprises at least one software application of the previously generated disk image and at least one new software application. The new disk image shares at least one data block of the previously generated disk image. A new node is added to the inheritance tree, and is associated with the new disk image. The new node is a child node of the node that is associated with the previously generated disk image.



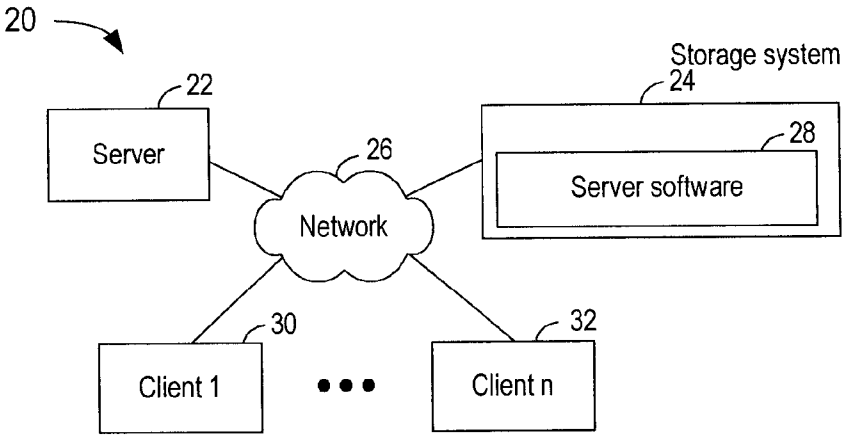

20
22
Server
26
Network
Storage system
24
28
Server software
30
Client 1
32
Client n

FIG. 1

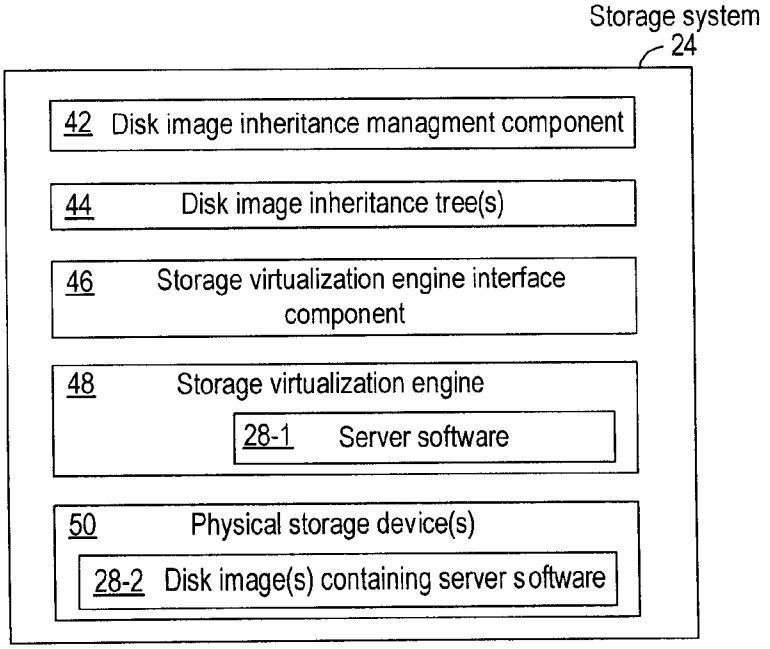

Storage system
24
42 Disk image inheritance managment component
44 Disk image inheritance tree(s)
46 Storage virtualization engine interface component
48 Storage virtualization engine
28-1 Server software
50 Physical storage device(s)
28-2 Disk image(s) containing server software

FIG. 2

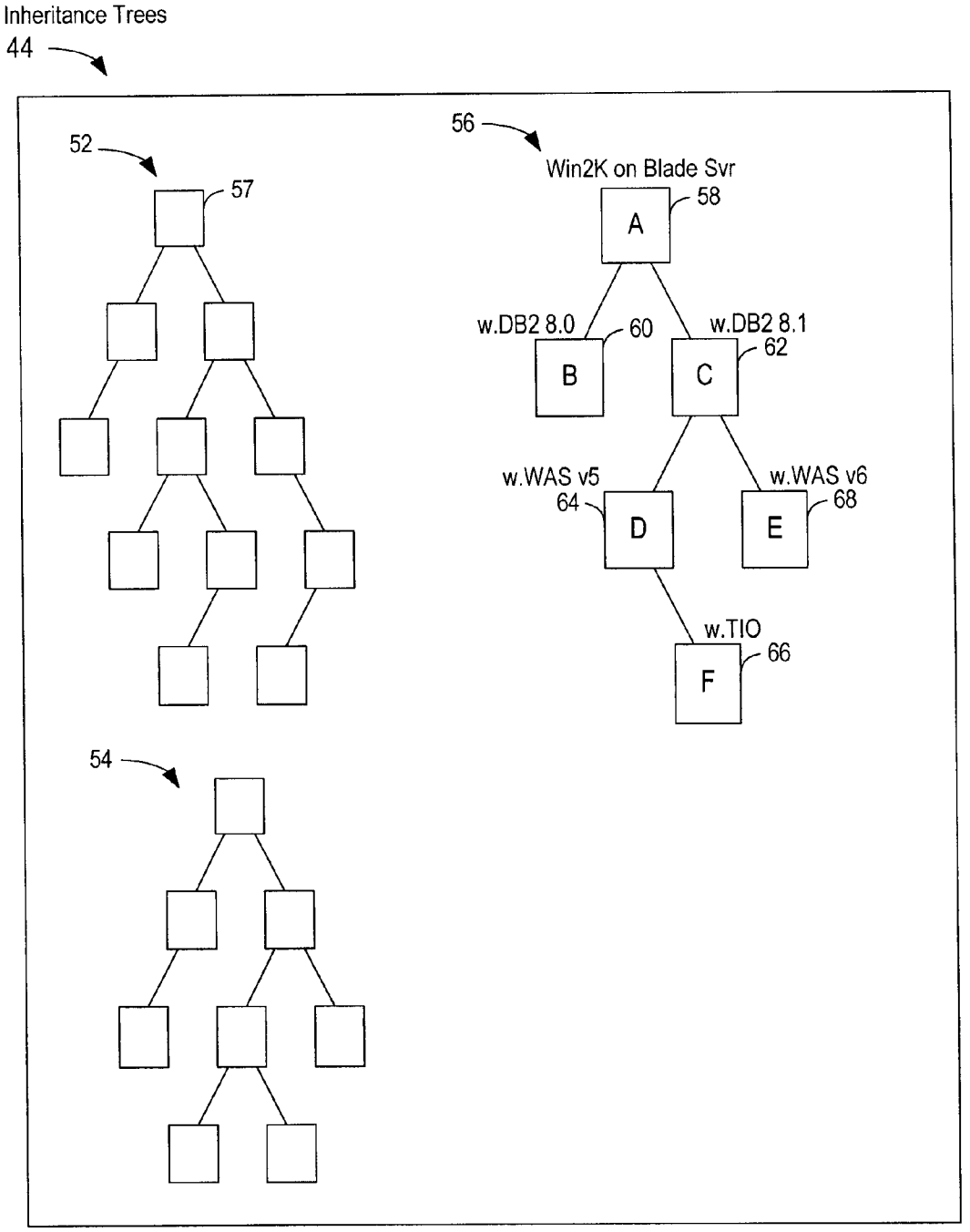

Inheritance Trees
44
52
57
56
Win2K on Blade Svr
58
A
w.DB2 8.0
60
w.DB2 8.1
62
B
C
w.WAS v5
64
w.WAS v6
68
D
E
w.TIO
66
F
54

FIG. 3

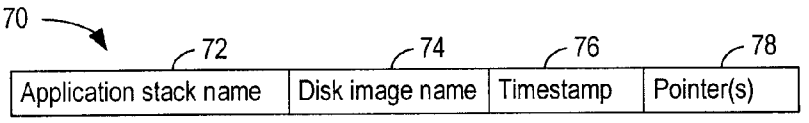

70
72
74
76
78
Application stack name
Disk image name
Timestamp
Pointer(s)

FIG. 4

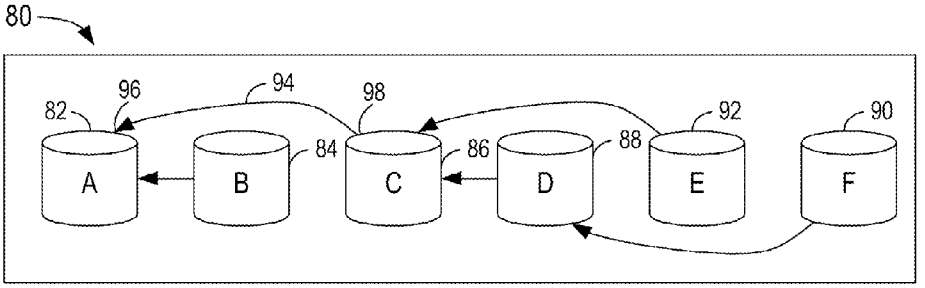


FIG. 5A

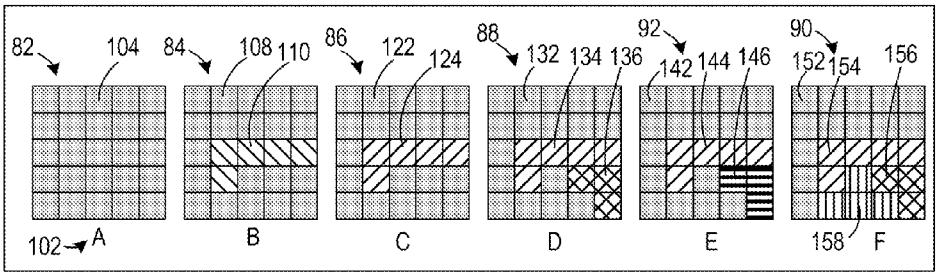


FIG. 5B

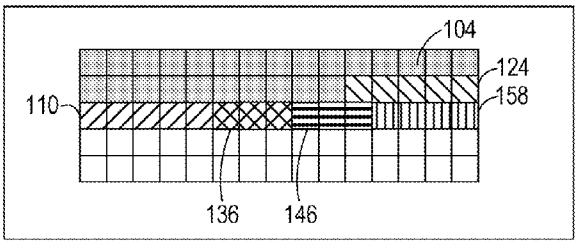


FIG. 5C

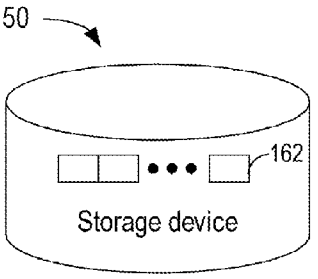


FIG. 5D

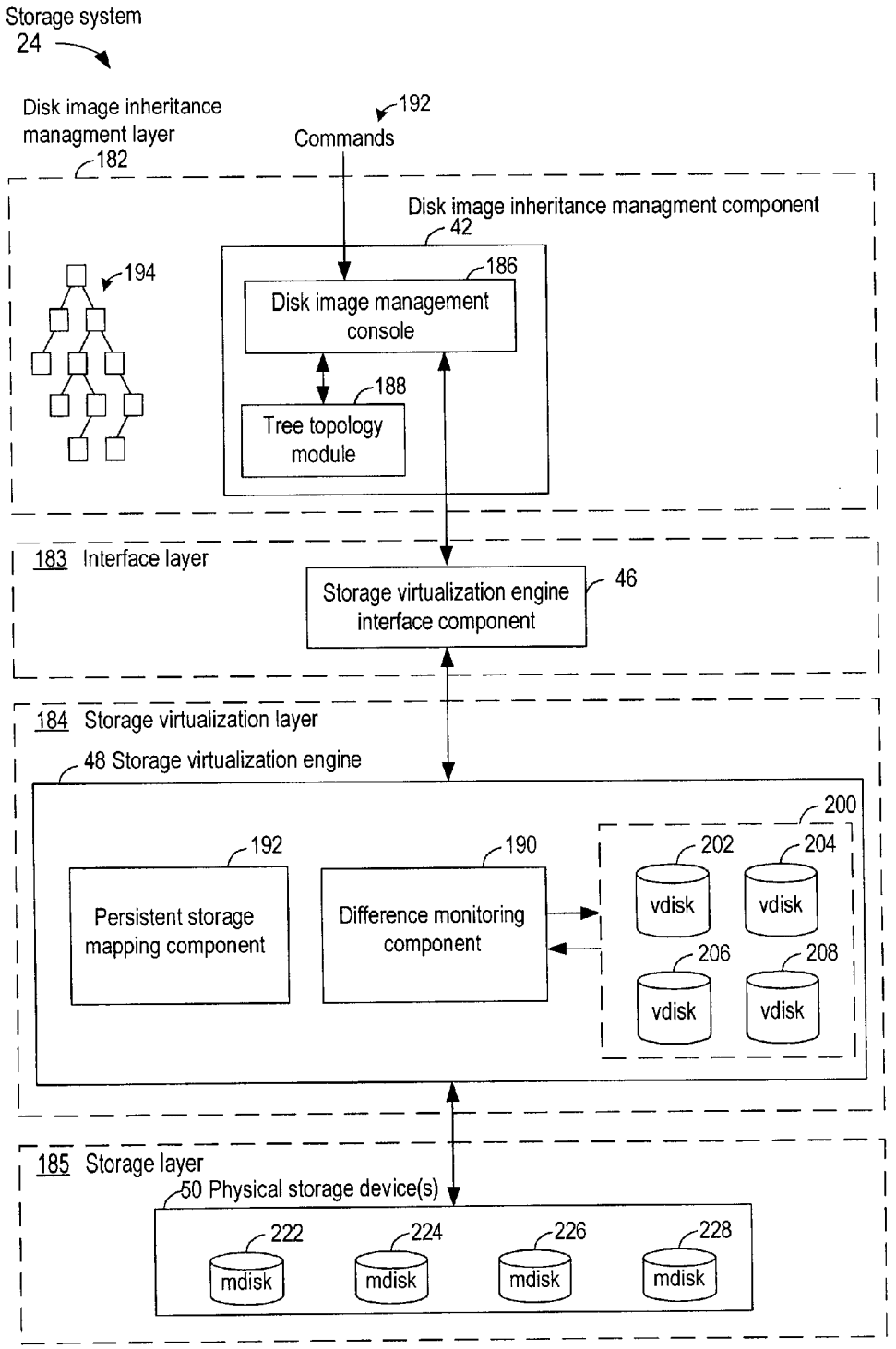

Storage system
24
Disk image inheritance
managment layer
182
192
Commands
Disk image inheritance managment component
42
194
186
Disk image management
console
188
Tree topology
module
183 Interface layer
Storage virtualization engine
interface component
46
184 Storage virtualization layer
48 Storage virtualization engine
200
192
Persistent storage
mapping component
190
Difference monitoring
component
202
204
vdisk
vdisk
206
208
vdisk
vdisk
185 Storage layer
50 Physical storage device(s)
222
224
226
228
mdisk
mdisk
mdisk
mdisk

FIG. 6

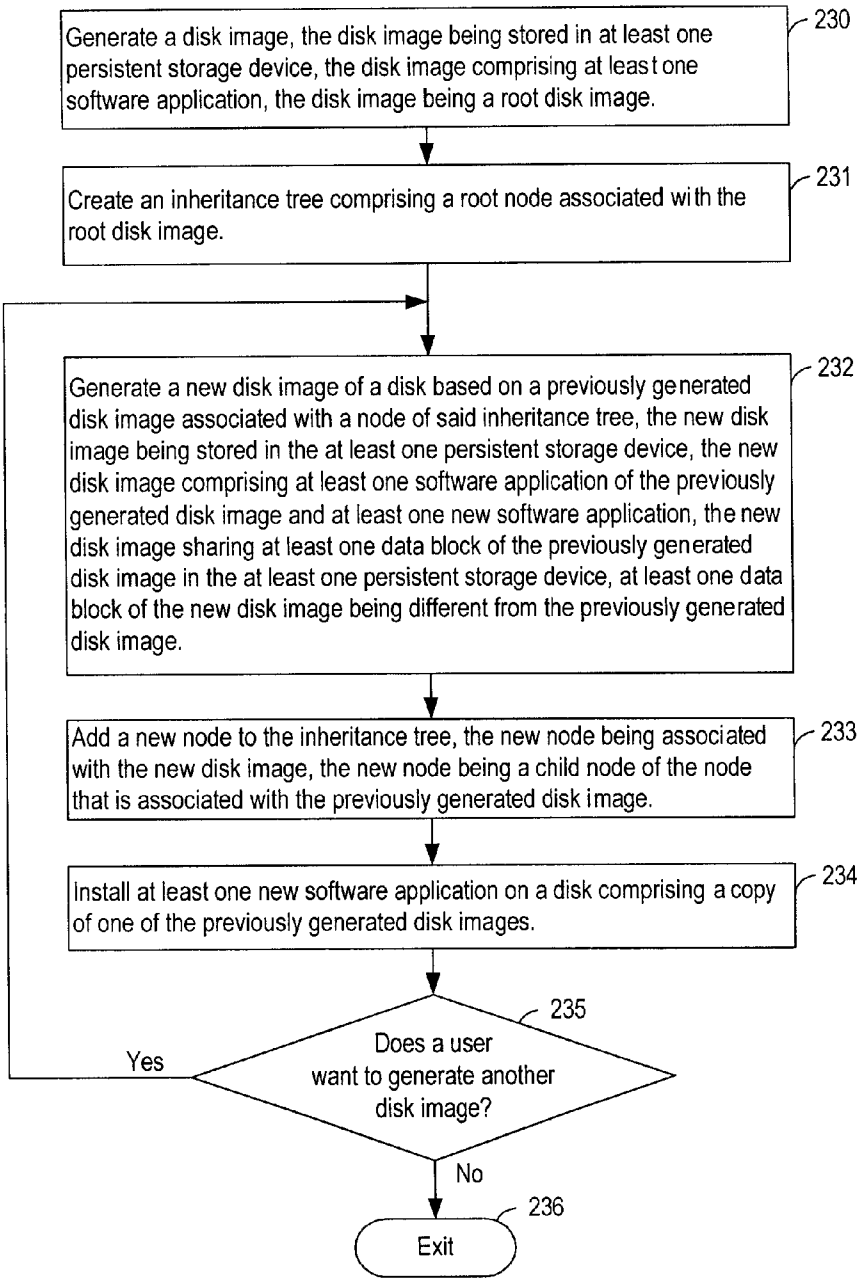

Generate a disk image, the disk image being stored in at least one persistent storage device, the disk image comprising at least one software application, the disk image being a root disk image.
230
Create an inheritance tree comprising a root node associated with the root disk image.
231
Generate a new disk image of a disk based on a previously generated disk image associated with a node of said inheritance tree, the new disk image being stored in the at least one persistent storage device, the new disk image comprising at least one software application of the previously generated disk image and at least one new software application, the new disk image sharing at least one data block of the previously generated disk image in the at least one persistent storage device, at least one data block of the new disk image being different from the previously generated disk image.
232
Add a new node to the inheritance tree, the new node being associated with the new disk image, the new node being a child node of the node that is associated with the previously generated disk image.
233
Install at least one new software application on a disk comprising a copy of one of the previously generated disk images.
234
Does a user want to generate another disk image?
235
Yes
No
Exit
236

FIG. 7

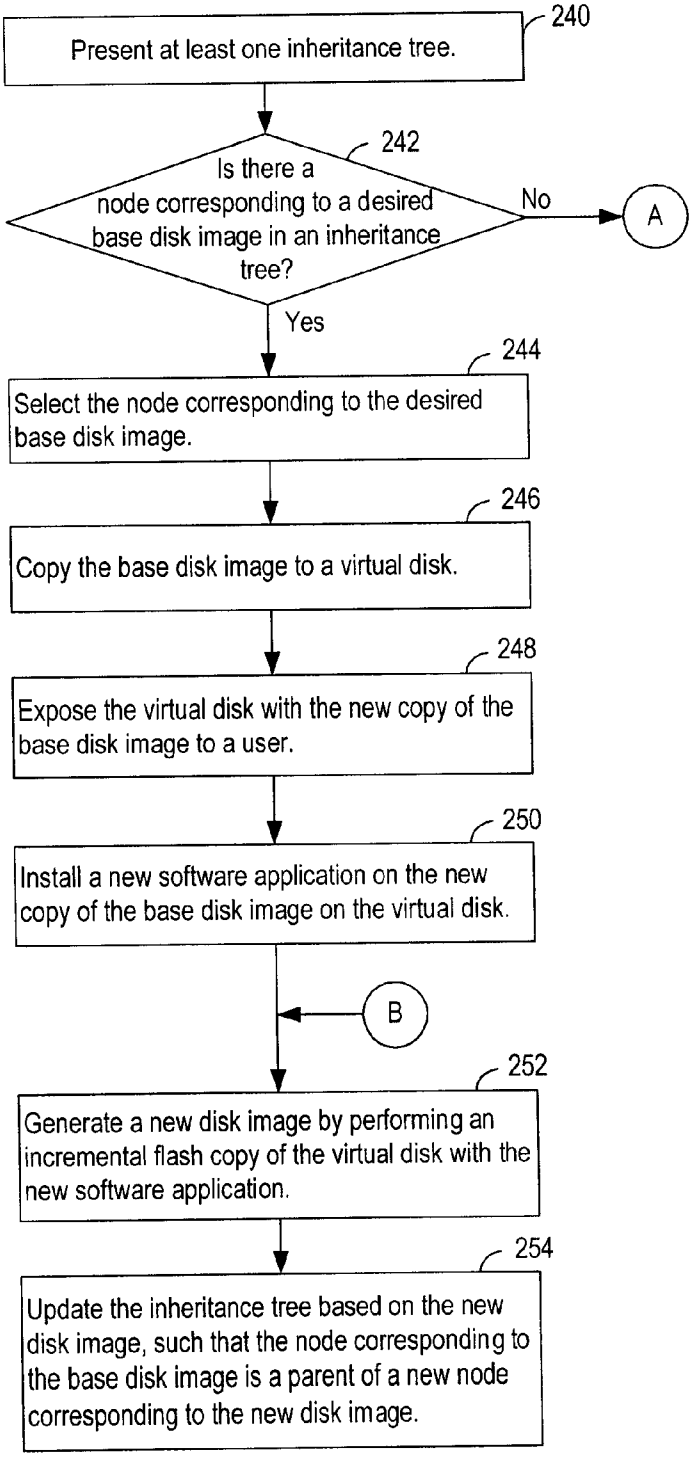


FIG. 8A

FIG. 8A
FIG. 8B

FIG. 8

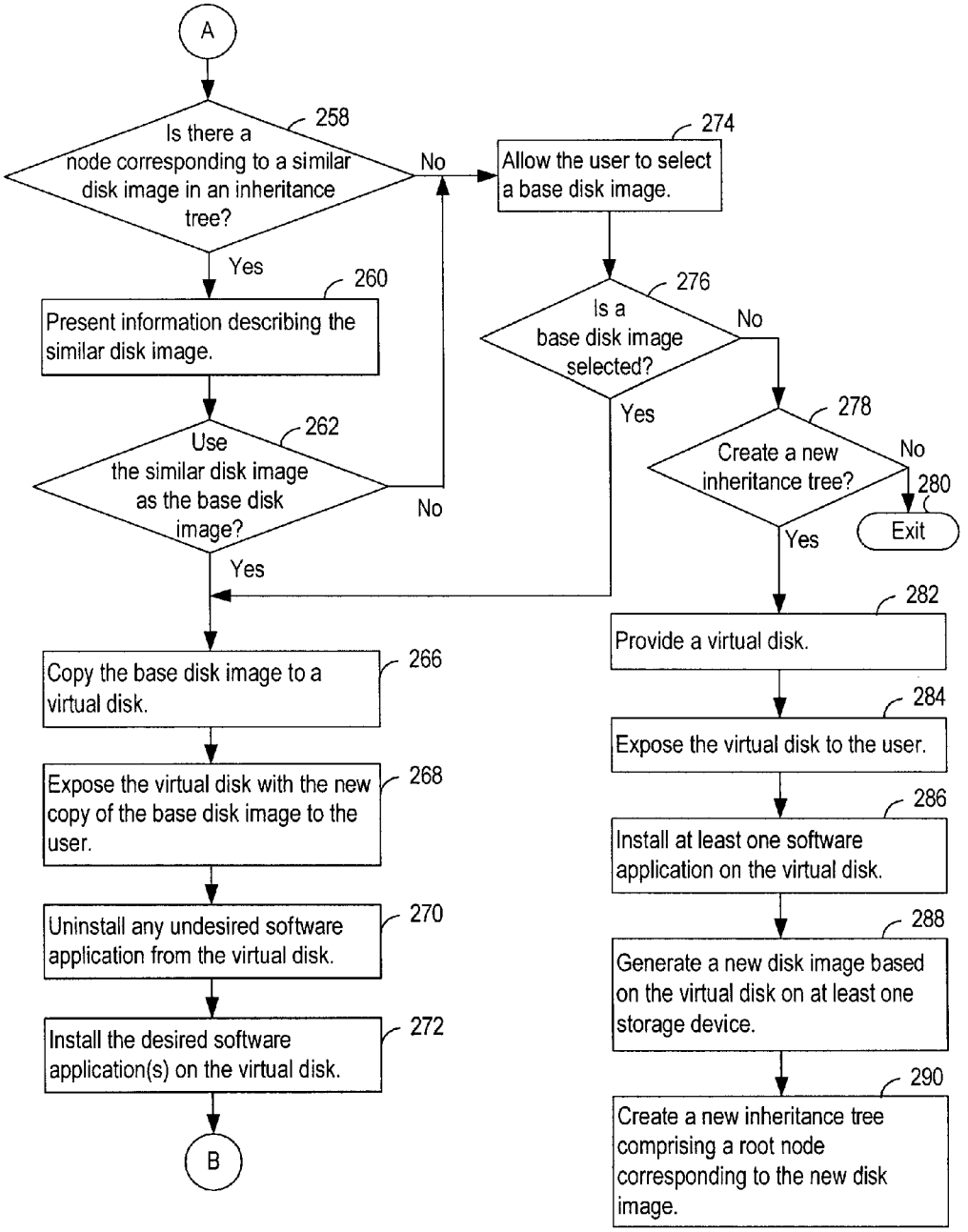

A
Is there a node corresponding to a similar disk image in an inheritance tree?
258
No
Yes
Allow the user to select a base disk image.
274
Present information describing the similar disk image.
260
Is a base disk image selected?
276
No
Yes
Use the similar disk image as the base disk image?
262
No
Yes
Create a new inheritance tree?
278
No
280
Exit
Yes
Copy the base disk image to a virtual disk.
266
Provide a virtual disk.
282
Expose the virtual disk with the new copy of the base disk image to the user.
268
Expose the virtual disk to the user.
284
Uninstall any undesired software application from the virtual disk.
270
Install at least one software application on the virtual disk.
286
Install the desired software application(s) on the virtual disk.
272
Generate a new disk image based on the virtual disk on at least one storage device.
288
B
Create a new inheritance tree comprising a root node corresponding to the new disk image.
290

FIG. 8B

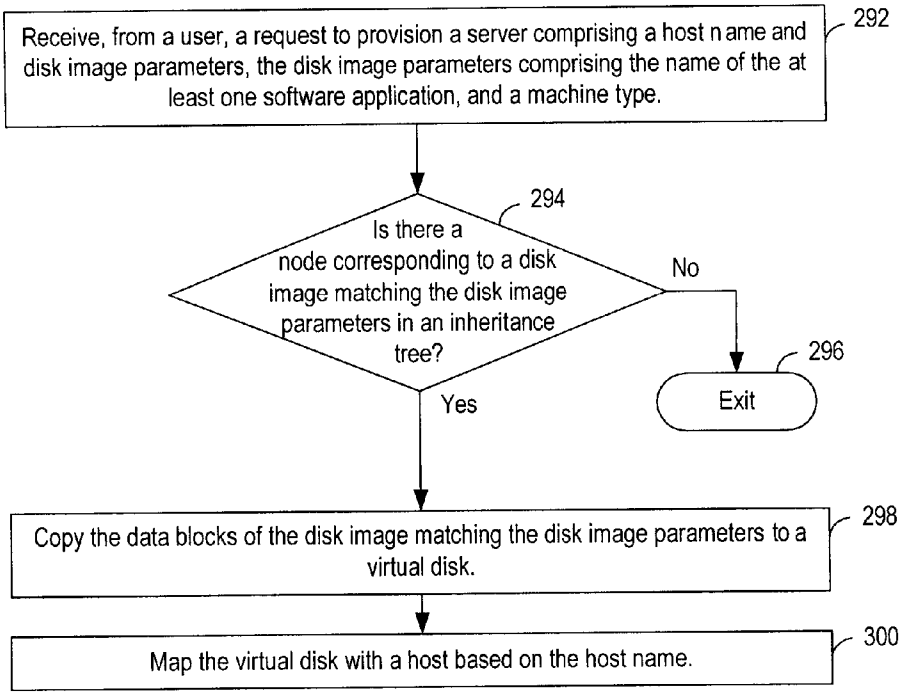

Receive, from a user, a request to provision a server comprising a host name and disk image parameters, the disk image parameters comprising the name of the at least one software application, and a machine type.
292
Is there a node corresponding to a disk image matching the disk image parameters in an inheritance tree?
294
No
Yes
Exit
296
Copy the data blocks of the disk image matching the disk image parameters to a virtual disk.
298
Map the virtual disk with a host based on the host name.
300

FIG. 9

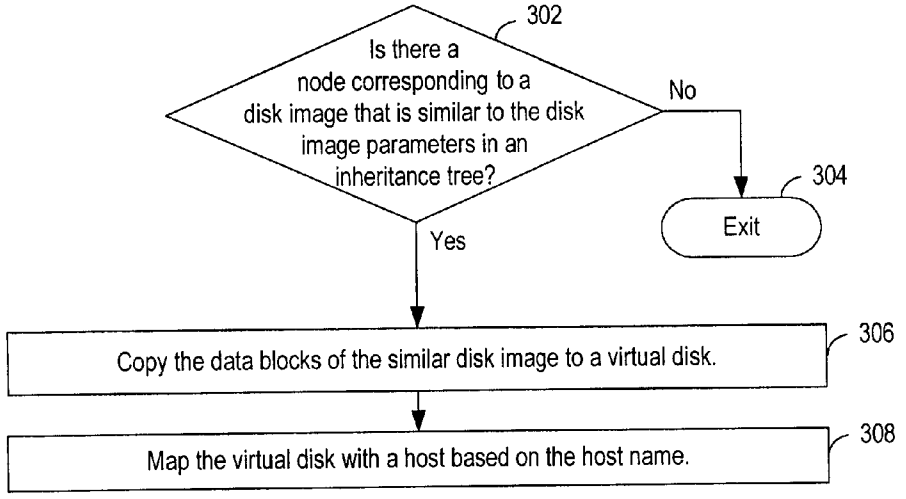

Is there a node corresponding to a disk image that is similar to the disk image parameters in an inheritance tree?
302
No
Yes
Exit
304
Copy the data blocks of the similar disk image to a virtual disk.
306
Map the virtual disk with a host based on the host name.
308

FIG. 10

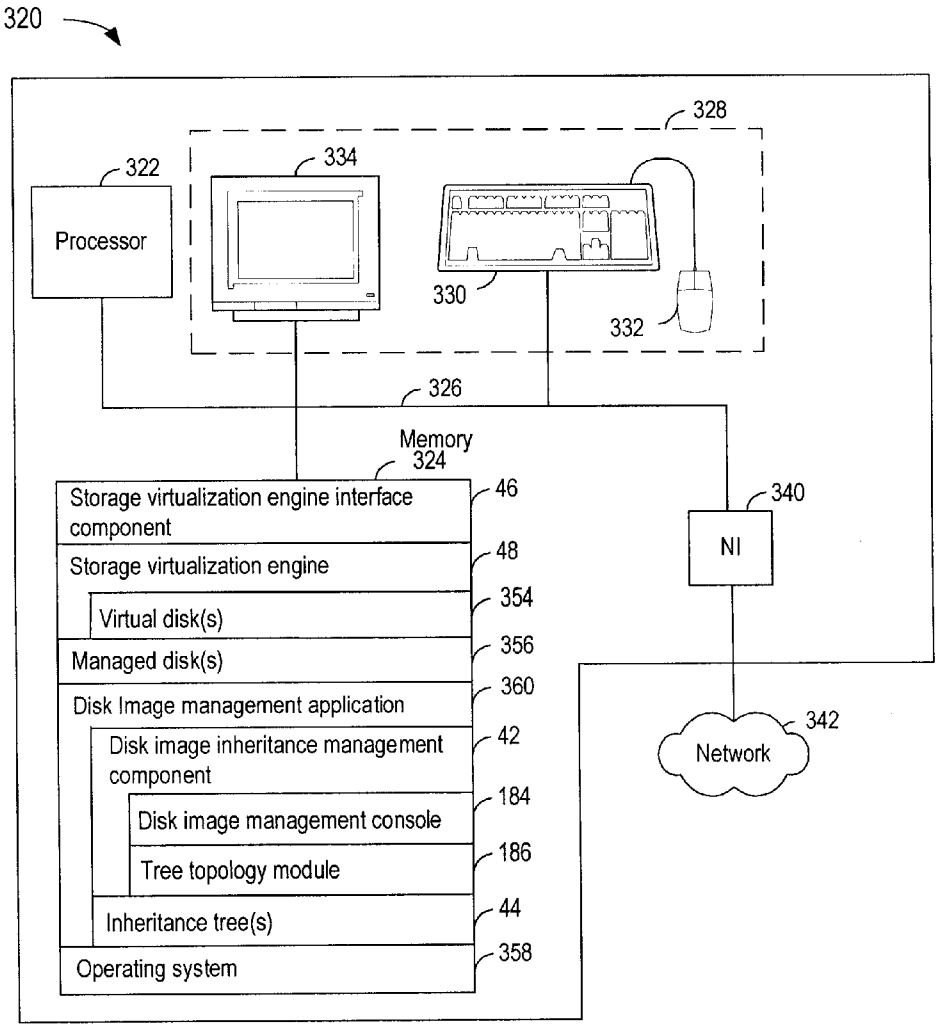

320
328
322
334
Processor
330
332
326
Memory
324
Storage virtualization engine interface component
46
Storage virtualization engine
48
Virtual disk(s)
354
Managed disk(s)
356
Disk Image management application
360
Disk image inheritance management component
42
Disk image management console
184
Tree topology module
186
Inheritance tree(s)
44
Operating system
358
NI
340
Network
342

FIG. 11

APPLICATION SERVER PROVISIONING BY DISK IMAGE INHERITANCE

BACKGROUND OF THE INVENTION

[0001] 1.0 Field of the Invention

[0002] This invention relates to application server provisioning; and in particular, this invention relates to application server provisioning by disk image inheritance.

[0003] 2.0 Description of the Related Art

[0004] In the current service-oriented Information Technology (IT) business market, fast and on-demand application server provisioning is a significant requirement for a data center. An "application server" is a computer that executes at least one software application in order to serve at least one client computer. A typical data center may host one or more customers; and each customer is typically provided with at least one application server. The software that is executed by an application server is referred to as application server software. The application server may have its own local disk, or may use a disk in a storage area network. The disk contains the software that is to be executed by the application server.

[0005] Various tools are used to create a full disk image to backup a disk in a computer system, and this backup image can be used to restore the disk in the event of a failure. To provision software for a new application server using one well-known method, a service provider copies a single full backup image of a disk that contains all the desired software applications to a disk from which the software will be executed by the application server. Using this method, an application server can typically be provisioned in a few minutes.

[0006] Application server software can have many options. Different customers typically use different application servers having, for example, different types of server machines and different software applications including operating systems. Using one technique, in order to provision application server software in a timely manner, the provisioning service provider prepares and maintains full disk images comprising many, or all, the application server software options. This results in a large number of full disk images which need to be stored. Each full disk image of the application server software contains all the software applications, typically including the operating system, of that application server software. Storing those full disk images consumes a large amount of storage. For example, assume that a data center has four different server machine types, three different operating systems, two versions of a database server, such as, the IBM® (Registered trademark of International Business Machines Corporation) DB2® (Registered trademark of International Business Machines Corporation) server, and two versions of an IBM WebSphere® (Registered trademark of International Business Machines Corporation) Application Server (WAS 6 and WAS 5). In addition, the DB2 server and WAS can be installed in same application server or in separate application servers. Therefore, in this example, there are a total of ninety-six (4×3×(2+2+2×2)=96) different possible options of application server software. To provide all possible different options, the service provider stores ninety-six full disk images of the application server software. Considering that the typical disk size of an application server is very large, for example, twenty gigabytes (20 G), storing ninety-six different full disk images of twenty gigabyte disks will consume 1.92 terabytes (96×20 G=1920 G) of storage space. In practice, a data center may have even more installation options and therefore an even larger storage requirement, which makes disk image-based application server software provisioning difficult to implement.

[0007] Therefore, there is a need for an improved technique for provisioning application server software.

SUMMARY OF THE INVENTION

[0008] To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, various embodiments of a method, computer program product, and storage system that can be used to provision a server are provided. In some embodiments, a disk image is generated. The disk image is stored in at least one persistent storage device. The disk image comprises at least one software application. The disk image is a root disk image. An inheritance tree comprising a root node associated with the root disk image is created. A new disk image of a disk is generated based on a previously generated disk image associated with a node of the inheritance tree. The new disk image is stored in at least one persistent storage device. The new disk image comprises at least one software application of the previously generated disk image and at least one new software application. The new disk image shares at least one data block of the previously generated disk image in at least one persistent storage device. At least one data block of the new disk image is different from the previously generated disk image. A new node is added to the inheritance tree. The new node is associated with the new disk image. The new node is a child node of the node that is associated with the previously generated disk image.

[0009] In some embodiments, in response to a user, the generating of the new disk image and adding the new node are repeated.

[0010] In another embodiment, the previously generated disk image comprises a plurality of software applications, and the new disk image comprises all of the plurality of the software applications of the previously generated disk image and at least one new software application.

[0011] In yet another embodiment, the disk is a virtual disk.

[0012] In another embodiment, the at least one persistent storage device comprises at least one managed disk.

[0013] In other embodiments, the generating of the disk image comprises performing a flash copy, and the generating of the new disk image comprises performing an incremental flash copy.

[0014] In some embodiments, the inheritance tree is graphically presented.

[0015] In various embodiments, the inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively. One of the nodes of the inheritance tree is selected; and the disk image associated with the one of the nodes that is selected is mapped to a host.

[0016] In another embodiment, the inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively. One node of the plurality of nodes of the inheritance tree is selected. The disk image associated with the one node that is selected is copied from the at least one persistent storage device to the disk. At least one new software application is installed on the disk.

[0017] In yet another embodiment, the inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively. A request to provision application server software is received. The request specifies at least one

software application. One node of the nodes of the inheritance tree is identified based on at least one software application of the request. The disk image corresponding to the one node that is identified is copied to a virtual disk. The virtual disk is mapped to the host.

[0018] In some embodiments, each node of the plurality of nodes comprises a disk image name, a timestamp, and an application stack name, and the identifying of the one node of the plurality of nodes of the inheritance tree is also based on the application stack name; and the disk image that is copied is based on the disk image name and the timestamp corresponding to the one node that is identified.

[0019] In various embodiments, the inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively. A request to provision an application server is received. The request specifies at least one software application. One node of the plurality of nodes of the inheritance tree is identified based on at least one software application of the request. The disk image corresponding to the one node that is identified is mapped to a host.

[0020] In various embodiments, a computer program product comprises a computer usable medium having computer usable program code for provisioning a server. The computer program product includes computer usable program code for generating a disk image, the disk image being stored in at least one persistent storage device. The disk image comprises at least one software application, the disk image being a root disk image. Also included is computer usable program code for creating an inheritance tree comprising a root node that is associated with the root disk image. Also included is computer usable program code for generating a new disk image of a disk based on a previously generated disk image associated with a node of the inheritance tree, the new disk image being stored in the at least one persistent storage device. The new disk image comprises at least one software application of the previously generated disk image and at least one new software application. The new disk image shares at least one data block of the previously generated disk image in at least one persistent storage device. At least one data block of the new disk image is different from the previously generated disk image. Also included is computer usable program code for adding a new node to the inheritance tree. The new node is associated with the new disk image. The new node is a child node of the node associated with the previously generated disk image.

[0021] In some embodiments, the computer usable program code for generating the disk image invokes a flash copy, and the computer usable program code for generating the new disk image invokes an incremental flash copy.

[0022] In another embodiment, the computer program product further comprises computer usable program code for presenting the inheritance tree.

[0023] In yet another embodiment, the computer program product further comprises computer usable program code for receiving a selection of a node of the inheritance tree; and computer usable program code for mapping the disk image associated with the node that is selected to a host.

[0024] In various embodiments, the inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively. In these various embodiments, the computer program product further comprises: computer usable program code for receiving a request to provision server software, the request specifying at least one software application and a host; computer usable program code for identifying one node of the plurality of nodes of the inheritance tree; computer usable program code for copying the disk image associated with the one node that is identified from the at least one persistent storage device to a virtual disk; and computer usable program code for mapping the virtual disk to the host.

[0025] In other embodiments, the request specifies a plurality of software applications. The computer program product further comprises: computer usable program code for identifying one similar node of the nodes of the inheritance tree associated with a similar disk image comprising less than all of the software applications of the request; and computer usable program code for copying the similar disk image to a virtual disk.

[0026] In yet other embodiments, each node of the plurality of nodes comprises a disk image name, a timestamp, and an application stack name, and the computer usable program code for identifying the one node of the plurality of nodes of the inheritance tree is based on the application stack name; and the computer usable program code for copying the disk image copies the disk image based on the disk image name and the timestamp corresponding to the one node that is identified.

[0027] In some embodiments, the inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, and the computer program product further comprises: computer usable program code for receiving a request to provision server software, the request specifying at least one software application and a host; computer usable program code for identifying one node of the plurality of nodes of the inheritance tree based on the at least one software application of the request; and computer usable program code for mapping the disk image corresponding to the one node that is identified to the host.

[0028] In various embodiments, a storage system comprises at least one processor, at least one persistent storage device and a memory. The persistent storage device(s) store a plurality of disk images sharing at least one data block. The memory stores an inheritance tree comprising a plurality of nodes, each node being associated with a disk image of the plurality of disk images. The plurality of nodes has a hierarchical relationship based on at least one software application associated with the plurality of disk images. The memory also stores instructions to be executed by the at least one processor. The instructions cause the at least one processor to generate a root disk image, the root disk image being stored in at least one persistent storage device, the root disk image comprising at least one software application. The instructions also cause the at least one processor to create a new inheritance tree comprising a root node that is associated with the root disk image. The instructions also cause the at least one processor to generate a new disk image of a disk based on one disk image of the plurality of disk images. The new disk image is stored in at least one persistent storage device. The new disk image comprises at least one software application of the one disk image and at least one new software application. The new disk image shares at least one data block of the one disk image in the at least one persistent storage device. At least one data block of the new disk image is different from the one disk image. The instructions also cause the processor to add a new node to the inheritance tree, the new node being associated with the new disk image, the new node being a child node of the node associated with the one disk image.

[0029] In some embodiments, the instructions that cause the at least one processor to generate the disk image invoke a flash copy, and the instructions that cause the at least one processor to generate the new disk image invoke an incremental flash copy.

[0030] In other embodiments, the memory further comprises instructions causing the at least one processor to present the inheritance tree.

[0031] In yet other embodiments, the memory further comprises instructions causing the at least one processor to receive a selection of a node of the inheritance tree, and map the disk image associated with the node that is selected to a server.

[0032] In various embodiments, the memory further comprises instructions causing the at least one processor to: select one node of the plurality of nodes of the inheritance tree; copy the disk image associated with the one node that is selected from the at least one persistent storage device to the disk; and install at least one new software application on the disk.

[0033] In other embodiments, the memory further comprises instructions causing the at least one processor to: receive a request to provision server software, the request specifying at least one software application; select one node of the nodes of the inheritance tree based on at least one software application of the request; copy the disk image corresponding to the one node that is identified to a virtual disk; and map the virtual disk to a host.

[0034] In yet other embodiments, each node comprises a disk image name, a timestamp, and an application stack name, and the one node of the plurality of nodes of the inheritance tree is selected based on the application stack name; and the disk image that is copied is selected based on the disk image name and the timestamp corresponding to the one node.

[0035] In some embodiments, the memory further comprises instructions causing the at least one processor to: receive a request to provision a server, the request specifying at least one software application and a host; identify one node of the plurality of nodes based on the at least one software application of the request; and map the disk image corresponding to the one node to the host.

[0036] In various embodiments, a computer-implemented method of provisioning a server using a storage system comprises generating, in the storage system, a disk image. The disk image comprises a plurality of data blocks. All of the plurality of data blocks of the disk image are stored in at least one persistent storage device. The disk image comprises at least one software application. The disk image is a root disk image. The disk image has a disk image name and a timestamp. The storage system receives an application stack name of the root disk image. In the storage system, an inheritance tree comprising a root node that is associated with the root disk image is created. The root node comprises the disk image name, the timestamp and the application stack name of the root disk image. In the storage system, a new disk image of a disk is generated based on a previously generated disk image associated with a node of the inheritance tree. The new disk image is stored in the at least one persistent storage device. The new disk image comprises each software application of the at least one software application of the previously generated disk image and at least one new software application. The new disk image shares at least one data block of the previously generated disk image in the at least one persistent storage device. At least one data block of the new disk image is different from the previously generated disk image. The new disk image has a new disk image name and a new timestamp. The storage system receives a new application stack name of the new disk image. The storage system adds a new node to the inheritance tree. The new node comprises the new disk image name, the new timestamp and the new application stack name. The new node is a child node of the node associated with the previously generated disk image.

[0037] In some embodiments, the storage system, in response to a user, repeats the generating of a new disk image, the receiving of the new application stack name, and the adding of the new node to the inheritance tree.

[0038] In other embodiments, the disk is a virtual disk and the at least one persistent storage device comprises at least one managed disk.

[0039] In yet other embodiments, the generating of the disk image comprises performing a flash copy, and the generating of a new disk image comprises performing an incremental flash copy.

[0040] In some embodiments, one node of the nodes of the inheritance tree is selected; and an application server is mapped to the disk image corresponding to the one node that is selected.

[0041] In various embodiments, a storage system comprises at least one processor, at least one persistent storage device and a memory. The persistent storage device(s) store a plurality of disk images sharing at least one data block. The memory stores an inheritance tree comprising a plurality of nodes, each node being associated with a disk image. A first node of the plurality of nodes is a root node. The plurality of nodes has a hierarchical relationship. The memory also stores instructions to be executed by the at least one processor, the instructions causing the at least one processor to generate a root disk image by performing a flash copy, the root disk image being stored in the at least one persistent storage device, the root disk image comprising at least one software application. The instructions cause the at least one processor to create an inheritance tree comprising a root node that is associated with the root disk image. The instructions cause the at least one processor to generate, by performing an incremental flash copy, a new disk image of a disk based on a one disk image of the plurality of disk images. The new disk image is stored in the at least one persistent storage device. The new disk image comprises at least one software application of the one disk image and at least one new software application. The new disk image shares at least one data block of the one disk image in the at least one persistent storage device. At least one data block of the new disk image is different from the one disk image. The instructions cause the at least one processor to add a new node to the inheritance tree, the new node being associated with the new disk image, the new node being a child node of the node associated with the one disk image.

[0042] In some embodiments, in the storage system the memory further comprises one or more instructions that cause the at least one processor to receive a request to provision an application server, the request specifying at least one software application and the application server; identify a particular node of the nodes of the inheritance tree based on the at least one software application of the request; copy a disk image associated with the particular node to a virtual disk; and map the virtual disk to the application server. In various embodiments, the virtual disk has the well-configured operating system, middleware and other desired application

software. After mapping the virtual disk to the application server, the application server is ready to run to provide service.

[0043] In this way, various embodiments of an improved technique for provisioning software are provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] The teachings of the present invention can be readily understood by considering the following description in conjunction with the accompanying drawings, in which:

[0045] FIG. **1** depicts a diagram of an illustrative data processing environment using various embodiments of the present invention;

[0046] FIG. **2** depicts a diagram of an embodiment of the storage system of FIG. **1**;

[0047] FIG. **3** depicts a diagram illustrating three exemplary inheritance trees of the storage system of FIG. **2**;

[0048] FIG. **4** depicts an embodiment node of an inheritance tree of FIG. **3**;

[0049] FIGS. **5**A, **5**B, **5**C and **5**D illustratively depict various aspects of an embodiment of disk image inheritance of the storage system of FIG. **2**;

[0050] FIG. **6** depicts a diagram of another embodiment of the storage system of FIG. **1**;

[0051] FIG. **7** depicts a flowchart of an embodiment of managing disk images for server provisioning;

[0052] FIG. **8** comprises FIGS. **8**A and **8**B which collectively depict a flowchart of an embodiment of managing disk images for server provisioning;

[0053] FIG. **9** depicts a flowchart of an embodiment of provisioning a server using a disk image inheritance tree;

[0054] FIG. **10** depicts a flowchart of another embodiment of provisioning a server using a disk image inheritance tree; and

[0055] FIG. **11** depicts an illustrative storage system which uses various embodiments of the present invention.

[0056] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to some of the figures.

DETAILED DESCRIPTION

[0057] After considering the following description, those skilled in the art will clearly realize that the teachings of the various embodiments of the present invention can be utilized to provision software. Various embodiments of a computer-implemented method, computer program product and storage system are provided. A disk image is generated. The disk image is stored in at least one persistent storage device. The disk image comprises at least one software application. The disk image is a root disk image. An inheritance tree comprising a root node associated with the root disk image is created. A new disk image of a disk is generated based on a previously generated disk image associated with a node of the inheritance tree. The new disk image is stored in at least one persistent storage device. The new disk image comprises at least one software application of the previously generated disk image and at least one new software application. The new disk image shares at least one data block of the previously generated disk image in at least one persistent storage device. At least one data block of the new disk image is different from the previously generated disk image. A new node is added to the inheritance tree. The new node is associated with the new disk image. The new node is a child node of the node that is associated with the previously generated disk image.

[0058] In some embodiments, in response to a user, the generating of the new disk image and adding the new node are repeated.

[0059] Using various embodiments of the present invention, a large number of disk images of server software can be efficiently stored in a storage system, and server software can be provisioned quickly.

[0060] FIG. **1** depicts a diagram of an illustrative data processing environment **20** using various embodiments of the present invention. A server **22** communicates with a storage system **24** through a network **26**. In some embodiments, the server **22** is implemented using a single computer system; in other embodiments, the server is implemented using a blade server. In various embodiments, the server **22** is an application server, and in some embodiments, a web application server. In other embodiments, the server **22** is not an application server. In yet other embodiments, the server **22** has an operating system and accesses the storage system **24** for other software applications.

[0061] In various embodiments, the storage system **24** is a storage area network. The storage system **24** stores server software **28** which is executed by the server **22**. The server software **28** comprises at least one software application, and typically comprises an operating system. In embodiments in which the server **22** is an application server, the server software **28** is application server software. In this description, the phrase "software application" is intended to encompass an operating system in addition to software applications such as database management systems, utilities, tools, and other non-operating system software.

[0062] Client systems, client one (**1**) **30** to client n **32** communicate with the server **22** through the network **26**. The client systems **30**, **32** are typically computer systems. The client system **30**, **32**, communicates with the server **22**. For example, a web browser is executing on client system **30** and is displaying a web page. In response to activating a button, or other control, on the web page on client system **30**, the web browser **30** sends a request for information to the server **22** through the network **26**. The server **22**, which is executing the server software **28**, processes the request and returns the requested information to the client system **30** via the network **26**.

[0063] The storage system **24** has at least one storage device. In various embodiments, the storage device(s) of the storage system **24** comprise at least one physical storage device such as a disk.

[0064] In general, a volume is a labeled logical unit, which can be a physical device or a logical device. In various embodiments, volumes in a storage area network are also called managed disks.

[0065] A managed disk is a logical disk, typically a redundant array of independent disks or partition thereof, that is exported by a storage subsystem to a storage area network. In some embodiments, the storage subsystem is part of the storage area network. In other embodiments, the storage subsystem is external to the storage area network. In some embodiments, a managed disk comprises one or more physical disks that are presented as a single logical disk. The managed disk provides usable blocks of physical storage and may not have a one-to-one correspondence with a physical disk. Each managed disk is divided into a number of storage

blocks. In some embodiments, a storage block is an extent. The extent size is a property of managed disk groups.

[0066] In various embodiments, the storage system **24** comprises at least one virtual storage device, such as a virtual disk. In various embodiments, the virtual disk is an abstraction layer which consolidates a physical storage subsystem into a single reservoir. A virtual disk is a logical disk that is presented to a server. Using a storage area network, a server, such as an application server, accesses the virtual disk. The server **22** accesses data on the virtual disk by requesting at least one specific data block of the virtual disk. In response to a request for at least one specific data block, the storage system **24** provides the requested data block(s) to the server **22**. For example, the server **22** retrieves a software application, or portion thereof, on the virtual disk for execution by requesting one or more specific data blocks of the virtual disk. The data blocks of a virtual disk are stored in storage blocks of a managed disk. In some embodiments, a virtual disk comprises a set of one or more extents of at least one managed disk. Therefore the virtual disk is stored on one or more physical disks.

[0067] Generally, a disk image is a set of data containing the complete content and structure of a data storage device. The data storage device may be a virtual disk or a physical disk. In various embodiments, the disk image is stored into a virtual disk, and in other embodiments the disk image is stored directly into a physical storage device. In various embodiments, the disk images are stored and managed using storage blocks and data blocks, and the storage system does not need to understand file system concepts. In some embodiments, the disk images are managed using volumes.

[0068] FIG. **2** depicts a diagram of an embodiment of the storage system **24** of FIG. **1**. A disk image inheritance management component **42** maintains at least one disk image inheritance tree **44**, which is also referred to as an inheritance tree. In some embodiments, the storage system **24** has a single inheritance tree. In other embodiments, the storage system **24** has a plurality of inheritance trees. A storage virtualization engine interface component **46** provides an interface to a storage virtualization engine **48**. In some embodiments, the storage virtualization engine **48** provides at least one and typically a plurality of virtual disks, and communicates with one or more physical storage devices **50**. In various embodiments, the server software **28-1** is provided using a virtual disk. A physical storage device provides persistent storage and is typically a disk. The physical storage device(s) **50** provides a repository for storing the disk image(s) containing the server software **28-2** associated with the inheritance tree (s) **44**. In various embodiments the physical storage device(s) are managed disks, and the virtual disks are stored on the managed disks.

[0069] Various embodiments will be described with respect to an application server and application server software. However, some embodiments of the present invention apply to other types of servers and server software.

[0070] FIG. **3** depicts a diagram illustrating three exemplary inheritance trees **52**, **54** and **56** of the storage system **24** of FIG. **2**. In various embodiments, an inheritance tree **52**, **54** and **56** indicates various heritage relationships among software applications that have a common root. Software applications are typically installed sequentially such that the installation of one software application is complete prior to starting the installation of another software application. In some embodiments, the heritage relationship depends on the order of installation of the software applications.

[0071] An inheritance tree has at least one node, and typically has a plurality of nodes. A node may have one or more child nodes. A node that has at least one child node is referred to as a parent node. A root node has no parent node. The exemplary inheritance trees **52**, **54** and **56** comprise a plurality of nodes **57**.

[0072] The phrase "application stack" refers to the one or more software applications that make up the application server software. For example, an application stack may comprise a DB2 v8.0 server installed on a Windows 2000 server.

[0073] Each node **57** of an inheritance tree corresponds to a disk image containing the application server software of an application server. Each disk image has a disk image name and a timestamp indicating a time of creation of the disk image. In some embodiments, each disk image associated with the same inheritance tree has the same disk image name and a different value of the timestamp. In other embodiments, the disk images of an inheritance tree have different disk image names. In various embodiments, the disk image name identifies a virtual disk. In other embodiments, the disk image name identifies a physical disk or a portion of a physical disk.

[0074] In various embodiments, each disk image is also associated with an application stack name. Each node **57** also corresponds to the application stack of the application server software of the corresponding disk image. The application stack name is provided by the user and is used to identify a particular distinguishing software application of the disk image such as the most recently added software application of the disk image. In some embodiments, the application stack name of the root node comprises the name of the root software application with a machine type. In other embodiments, an inheritance tree is also associated with a machine type, for example, a particular blade server, and the application stack name of the root node comprises the name of the root software application without a machine type. The application stack name is used to provide a list of all the software applications of the application stack. For example, in some embodiments, the software applications of an application stack of a particular node can be identified by displaying the application stack name of the particular node and the application stack name of all its ancestor nodes.

[0075] Exemplary inheritance tree **56** will now be described. Inheritance tree **56** has a root node **58**, labeled "A," that corresponds to a disk image that comprises a Windows 2000 server that executes on a blade server. In this description, the Windows 2000 server that executes on a blade server will be referred to as the Windows 2000 server. The disk image that corresponds to the root node **58** is also referred to as a root disk image. This root disk image has an exemplary disk image name of "Win2K" and the exemplary timestamp is "200608230600" which in this example corresponds to Aug. 23, 2006 at 6:00 am. The application stack name of this disk image is "Win2K on Blade Svr" and is shown in the diagram of the inheritance tree **56**. The disk image that corresponds to node **58** can be used for provisioning other application servers that comprise the Windows 2000 server and in some embodiments for recovery of an application server. The root node of the inheritance tree typically corresponds to a disk image containing a first software application that is installed to provision application server software. The first software application is typically an operating system.

[0076] In this example, a user installs the DB2 v8.0 server on the disk that comprises the Windows 2000 server, and makes a disk image of the disk. In some embodiments, the user is a system administrator. This exemplary disk image is also named "Win2K" and has an exemplary timestamp of "200608230800" which in this example corresponds to Aug. 23, 2006 at 8:00 am. The application stack name of this disk image is "w.DB2 8.0" which indicates the new software application. This disk image can be used to provision application server software comprising the DB2 8.0 server on the Windows 2000 server. In the inheritance tree **56**, node **60**, labeled "B" corresponds to the disk image named "Win2K" with the timestamp of "200608230800". Node **60** is a child of node **58**. Therefore, the exemplary disk image named "Win2K" with the timestamp of "200608230800" is a child disk image of the exemplary disk image named "Win2K" with a timestamp of "200608230600". Node **58** is a parent of node **60**. The disk image named "Win2K" 58 with the timestamp of "200608230600" is a parent of the disk image named "Win2K" with the timestamp of "200608230800".

[0077] In this example, the user also installs the DB2 v8.1 server on a disk comprising the Windows 2000 server, and makes a disk image of that disk. This exemplary disk image is named "Win2K" and has a timestamp of "200608231000". The application stack name of this disk image is "w.DB2 v8.1". Node **62**, labeled "C," corresponds to the disk image named "Win2K" with the timestamp of "200608231000". The disk image named "Win2K" with the timestamp of "200608231000" can be used to provision application server software comprising the DB2 8.1 server on a Windows 2000 server. Node **62** is a child of node **58**. The disk image named "Win2K" with the timestamp of "200608231000 is a child of disk image "Win2K" with a timestamp of "200608230600." Node **58** is a parent of node **62**. The disk image named "Win2K" 58 with the timestamp of "200608230600" is a parent of the disk image named "Win2K" with the timestamp of "200608231000".

[0078] The user installs the WebSphere Application Server v5 on a disk comprising a copy of the disk image "Win2K" with a timestamp of "200608231000" and makes a disk image of that disk. This disk image is named "Win2K" and has a timestamp of "200608231200". The application stack name of this disk image is "w.WAS v5". Node **64**, labeled "D," corresponds to the disk image named "Win2K" with the timestamp of "200608231200". The disk image named "Win2K" with the timestamp of "200608231200" comprises WebSphere Application Server v5, the DB2 8.1 server and the Windows 2000 server. Node **64** is a child of node **62**. The disk image named "Win2K" with the timestamp of "200608231200" is a child of the disk image named "Win2K" with the timestamp of "200610151000". Node **62** is a parent of node **64**, and the disk image named "Win2K" with the timestamp of "200608231000" is a parent of the disk image named "Win2K" with the timestamp of "200608231200".

[0079] The user then installs Tivoli® (Registered Trademark of IBM Corporation) Intelligent Orchestration on a disk having a copy of the disk image named "Win2K" with the timestamp of "200608231200" and makes another disk image. This disk image is named "Win2K" and has a timestamp of "200608231400". The application stack name of this disk image is "w. TIO". Node **66**, labeled "F", corresponds to the disk image named "Win2K" with the timestamp of "200608231400". The disk image named "Win2K" with the timestamp of "200608231400" comprises Tivoli Intelligent Orchestration, WebSphere Application Server v5, the DB2 8.1 server and the Windows 2000 server. Node **66** is a child of node **64**. The disk image named "Win2K" with the timestamp of "200608231400" is a child of the disk image named "Win2K" with the timestamp of "200608231200".

[0080] In addition, the user installs WebSphere Application Server v6 on a disk comprising the DB2 8.1 server on the Windows 2000 server, and makes a disk image. This disk image is named "Win2K" and has a timestamp of "200608231600". The application stack name of this disk image is "w. WAS v6". In the inheritance tree, node **68**, labeled "E", corresponds to the disk image named "Win2K" with the timestamp of "200608231600".

[0081] In the exemplary inheritance tree **56**, the root disk image has a single software application. In other embodiments, the root disk image comprises a plurality of software applications. In addition, in the exemplary inheritance tree **56**, a child disk image has one software application that differs from the software application(s) of its parent disk image. In other embodiments, a child disk image has a plurality of software applications that are different from the software application(s) of its parent disk image.

[0082] A child node has one or more ancestor nodes. A parent node is an ancestor of its child node, and the ancestors of a child node continue up to the root node. For example, the ancestors of node **66**, labeled "F", comprise nodes **64**, **62** and **58**.

[0083] FIG. **4** depicts an embodiment of a node **70** of an inheritance tree of FIG. **3**. The node **70** comprises an application stack name (Application stack name) **72**, a disk image name (Disk image name) **74**, a timestamp (Timestamp) **76** and at least one pointer (Pointer(s)) **78**. The disk image name **74** is the name of the disk image. The timestamp **76** indicates the time of creation of the disk image. The pointer(s) **78** refer to a node associated with a parent disk image, if any, and node(s) associated with child image(s), if any, of the disk image that is specified by the disk image name **74** and timestamp **76**. The combination of the disk image name **74** and timestamp **76** are used to identify a particular disk image in the physical storage device(s). For example, in some embodiments, the disk images of an inheritance tree have the same name and are differentiated by their timestamp. In various embodiments, the application stack name is presented to a user to identify a desired application stack, and the disk image is identified based on the disk image name and timestamp associated with the application stack name. In some embodiments, the application stack name is omitted.

[0084] FIGS. **5**A, **5**B, **5**C and **5**D illustratively depict various aspects of an embodiment of a technique of disk image inheritance of the storage system of FIG. **2**. FIG. **5**A illustrates the relationships of the disk images corresponding to inheritance tree **56** of FIG. **3**. Disk images **82**, **84**, **86**, **88**, **90** and **92** of FIG. **5**A correspond to nodes **58**, **60**, **62**, **64**, **66** and **68**, respectively, of FIG. **3**. In FIG. **5**A, the exemplary disk images **82**, **84**, **86**, **88**, **90** and **92** are also shown with the label, "A", "B","° C., "D", "F" and "E", respectively, of the corresponding node. The arrows **94** indicate a parent-child relationship. The tip **96** of the arrow **94** points to the parent disk image, and the other end **98** of the arrow **94** is at the child disk image. For example, the disk image **82** has a name of "Win2K" with a timestamp of "200608230600" and corresponds to node **58** of the inheritance tree **56** of FIG. **3**. The disk image **86** has a name of "Win2k" with a timestamp of "200608231000" and corresponds to node **62** of the inherit-

ance tree **56** of FIG. **3**. As illustrated by arrow **94**, disk image **82** is a parent of child disk image **86**. In various embodiments, FIG. **5**A, the disk images **82**, **84**, **86**, **88**, **90** and **92** are stored on one or more physical disks.

[0085] In response to generating a new disk image comprising a new software application that is installed on a copy of an existing disk image that is associated with an existing node of an inheritance tree, the disk image inheritance management component **42** (FIG. **2**) records the heritage relationship of the new disk image in the inheritance tree. In various embodiments, a single inheritance tree is used to store multiple heritage relationship topologies which comprise many, and in some embodiments all, of the application server software options. In some embodiments, multiple inheritance trees are created to store multiple heritage relationship topologies that encompass many, and in some embodiments all, application server software options and each inheritance tree has different a different software application on its root disk image.

[0086] An application server is allocated a specified number of data blocks of disk storage for the application server software. A disk image of the application server's disk storage also comprises the allocated number of data blocks. In various embodiments, the content of many data blocks of a child disk image is the same as the content of the data blocks of its parent disk image, and these data blocks are referred to as being the same. In various embodiments, a difference monitoring component of the storage virtualization engine **48** (FIG. **2**) identifies one or more data blocks that have different content between the parent and child disk images, and these data blocks are referred to as different data blocks.

[0087] FIG. **5**B graphically illustrates the differences between the illustrative disk images of FIG. **5**A. The labels **102** of the corresponding nodes are shown below the disk images **82**, **84**, **86**, **88**, **90** and **92**. The first disk image **82** comprises only the root software application associated with node "A" **58** of FIG. **3**. Each square **104** represents a data block. The first disk image **82** comprises a plurality of data blocks **104** which are shaded. In various embodiments, the root software application uses less than all of the data blocks that are allocated to the application server, and therefore less than all data blocks of the first disk image **82**. In this example, the root software application is the Windows 2000 server.

[0088] The second disk image **84** is associated with node "B" **60** of FIG. **3**. The second disk image **84** is a child disk image of the first disk image **82**. The storage virtualization engine compares the data blocks of the first and second disk images, **82** and **84**, respectively, and identifies the different data blocks. The data blocks **108** of the second disk image **84** that are the same as in the first disk image **82** are indicated using the same shading as in the first disk image **82**. The data blocks **110** of the second disk image that are different from the first disk image **82** are hatched, and not shaded. In this example, the first disk image comprises the Windows 2000 server; and the second disk image comprises the DB2 8.0 server on the Windows 2000 server. In this example, the data blocks **110** which are different result from the installation of the DB2 8.0 server.

[0089] The third disk image **86** is associated with node "C" **62** of FIG. **3**. The storage virtualization engine compares the data blocks of the first and third disk images, **82** and **86**, respectively, and identifies the different data blocks. The data blocks **122** of the third disk image **86** that are the same as in the first disk image **82** are shaded as in the first disk image **82**. The data blocks **124** which are different from the first disk image **82** are hatched, and not shaded. The third disk image **86** comprises the DB2 8.1 server installed on a Windows 2000 server. In this example, the data blocks **120** which are different result from the installation of the DB2 8.1 server.

[0090] The fourth disk image **88** is associated with node "D" **64** of FIG. **3**. The fourth disk image **88** is a child of the third disk image **86** which is a child of the root disk image **82**. The fourth disk image **88** comprises WAS v5, the DB2 8.1 server, and the Windows 2000 server. The storage virtualization engine compares the data blocks of the third and fourth disk images, **86** and **88**, respectively, and identifies the different data blocks. The data blocks **136** which are changed in response to the installation of WAS v5, and therefore different from the third disk image **86**, are cross-hatched. The data blocks **132** that are the same as in the first and third disk images **82** and **86** are shaded as in the first and third disk images **82** and **86**, respectively. The data blocks **134** that are the same as the changed data blocks of the third disk image **86** are hatched as in the third disk image **86**.

[0091] The fifth disk image **92** is associated with node "E" **68** of FIG. **3**. The fifth disk image **92** is a child disk image of the third disk image **86** which is a child disk image of the root disk image **82**. The fifth disk image **92** comprises WAS v6, the DB2 8.1 server and the Windows 2000 server. The storage virtualization engine compares the data blocks of the third and fifth disk images, **86** and **92**, respectively, and identifies the data blocks which are different. The data blocks **146** which are different from the third disk image **86** are indicated with parallel horizontal lines. In this example, the data blocks **146** which are different result from the installation of WAS v6. The data blocks **142** of the fifth disk image **92** that are the same as in the first and third disk images **82** and **86** are shaded as in the first and third disk images, **82** and **86**, respectively. The data blocks **144** of the fifth disk image **92** that are the same as the changed data blocks of the disk third image **86** are hatched as in the third disk image **86**.

[0092] The sixth disk image **90** is associated with node "F" **66** of FIG. **3**. The sixth disk image **90** is a child disk image of the fourth disk image **88** which is a child disk image of the third disk image **86** which is a child of the root disk image **82**. The sixth disk image **90** comprises TIO, WAS v5, the DB2 8.1 server and the Windows 2000 server. The storage virtualization engine compares the data blocks of the sixth and fourth disk images, **90** and **88**, respectively. The data blocks **158** which are different from the fourth disk image **88**, are hatched with parallel vertical lines. In this example, the data blocks **158** which are different result from the installation of TIO. The data blocks **152** that are the same as in the first, third and fourth disk images, **82**, **86** and **88** are shaded as in the first, third and fourth disk images, **82**, **86** and **88**, respectively. The data blocks **154** that are the same as the changed data blocks of the third disk image **86** and the fourth disk image **88** are hatched as shown in the third disk image **86** and the fourth disk image **88**. The data blocks **156** that are the same as the changed data blocks of the fourth disk image **88** are cross-hatched as in the fourth disk image **88**.

[0093] The disk images are stored in at least one physical storage device. The storage virtualization engine **48** of FIG. **2** maps one or more data blocks of the disk image into one or more storage blocks of a storage device. Typically, all of the data blocks of a new root disk image are mapped to one or more new storage blocks. In various embodiments, a child disk image is considered to inherit at least one data block of its

parent disk image. The child disk image inherits each data block which is the same as in its parent disk image. Typically, for a child disk image, the storage virtualization engine creates at least one new storage block for the one or more data blocks that are different from its parent disk image, and the different data block or blocks of the child disk image are stored in the new storage block(s). In various embodiments, the storage virtualization engine maps each data block of the child disk image that is different from its parent disk image to one or more new storage blocks. The one or more data blocks of the child disk image that are the same as in its parent disk image are not mapped to the new storage block(s) and the existing mapping of those data blocks is used for the child disk image. The storage virtualization engine stores the mapping in a data structure. In some embodiments, a child disk image is considered to share data block(s) with its parent disk image even when a data block is shared with an ancestor disk image of its parent disk image. In various embodiments, at least one data block of at least one storage block of an ancestor disk image of a child disk image is shared with the child disk image. In various embodiments, since at least one data block of a child disk image is different from its parent's data blocks, sharing one or more data blocks that are the same as in an ancestor disk image will reduce consumption of storage space. Therefore, various embodiments of the present invention efficiently store disk images.

[0094] FIG. **5**C illustratively depicts data blocks that are stored in the storage blocks in persistent storage. The storage virtualization engine stores all the data blocks **104** of the first or root disk image **82** (FIG. **5**B). For the child disk images **84**, **86**, **88**, **90** and **92**, the storage virtualization engine maps one or more data blocks that are different from their respective parent disk images, **110**, **124**, **136**, **146**, and **158** to at least one storage block. The storage virtualization engine stores the one or more data blocks of the child disk images **84**, **86**, **88**, **90** and **92** that are different from their respective parent disk images in at least one storage block in at least one storage device.

[0095] FIG. **5**D depicts an illustrative physical storage device **50-1** of the storage system **24** of FIG. **2**. The storage device **50-1** provides persistent storage. The data blocks of FIG. **5**C are stored in the storage blocks **162** of storage device **50-1**. In some embodiments, a storage block **162** stores the same amount of data as a data block. In other embodiments, a storage block **162** stores an amount of data corresponding to a plurality of data blocks. In some embodiments, the storage blocks have the same size. In other embodiments, the storage blocks have different sizes.

[0096] The storage virtualization engine maps the location of the data blocks and storage blocks of the disk images in the storage device. The storage virtualization engine contains the location and mapping of the data blocks of the root disk image to the storage blocks of the persistent storage. The storage virtualization engine contains and maintains, for each child disk image, a mapping of the location of the shared data block(s) to storage block(s), in addition to a mapping of the location of different data block(s) to storage block(s).

[0097] FIG. **6** depicts a diagram of another embodiment of the storage system **24** of FIG. **1**. In various embodiments, the storage system **24** is a storage area network (SAN).

[0098] In some embodiments, the storage system **24** is implemented in layers. The layers comprise a disk image inheritance management layer **182**, an interface layer **183**, a storage virtualization layer **184** and a storage layer **185**. The disk image inheritance management layer **182** comprises the disk image inheritance management component **42**. The interface layer **183** comprises the storage virtualization engine interface component **46**. The storage virtualization layer **184** comprises the storage virtualization engine **48**. The storage layer **185** comprises storage device(s) **50**. In other embodiments, layers are not used.

[0099] The disk image inheritance management component **42** comprises a disk image management console **186** and a tree topology module **188**. The disk image management console **186** provides a user interface. The disk image management console **186** is implemented using one or more software modules. In various embodiments, the disk image management console **186** provides a command line interface. In some embodiments, the disk image management console provides a graphical user interface. The disk image management console **186** receives and processes commands **192**, from a user. At least one of the commands **192** is to provision application server software using an existing disk image. At least another one of the commands is to create or generate a new disk image. The tree topology module **188** maintains one or more inheritance trees **194** corresponding to the disk images of the application server software that are stored in the physical storage device(s) **50**. In some embodiments, the disk image management console **186** graphically presents at least one inheritance tree, for example, as illustrated in FIG. **3**, on a display. The disk image management console **186** communicates with the storage virtualization engine interface component **46**. In some embodiments, the disk image management console **186** is accessed at the storage system, and in other embodiments the disk image management console **186** is accessed by a user at a computer via a network.

[0100] The storage virtualization engine interface component **46** provides a programming interface to the storage virtualization engine **48**. In some embodiments, the storage virtualization engine interface component **46** is separate from the storage virtualization engine **48**; in other embodiments, the storage virtualization engine interface component **46** is included in the storage virtualization engine **48**. The storage virtualization engine interface component **46** receives storage system commands from the disk image management console **186** and invokes the storage virtualization engine **48** to process the storage system commands. In various embodiments, the storage virtualization engine interface component **46** is implemented as part of a storage virtualization engine console which also provides a command line interface to the storage virtualization engine **48**, and in some embodiments, a graphical user interface to the storage virtualization engine.

[0101] In some embodiments, the storage virtualization engine **48** comprises a difference monitoring component **190** and a persistent storage mapping component **192**. In other embodiments, the storage virtualization engine **48** does not have a difference monitoring component and persistent storage mapping component, and performs the functions of those components. The storage virtualization engine **48** has a set **202** of one or more virtual disks **204**, **206**, **208**, and **210**. The difference monitoring component **190** accesses the set **202** of virtual disks **204**, **206**, **208**, and **210**.

[0102] In various embodiments, the physical storage device (s) **50** comprise at least one managed disk (mdisk) **222**, **224**, **226** and **228**. The persistent storage mapping component **192** maps the data blocks of a virtual disk **202**, **204**, **206**, **208** to the storage blocks of a managed disk **222**, **224**, **226** and **228**. In other embodiments, the physical storage device(s) **50** are not managed disks.

[0103] In various embodiments, flash copy is used to generate a disk image which is a full image copy of a disk. The disk image is stored in one or more storage devices. In various embodiments, a disk image of a virtual disk is stored into another virtual disk. Flash copy is also referred to as a point-in-time copy or as an instance of a time-zero copy (TO). Flash copy is used to generate a root disk image comprising all allocated data blocks of a disk in persistent storage. The flash copy operation is used to copy all the data blocks of root disk image **82** (FIG. **5**B) to persistent storage as illustrated in FIG. **5**C. In various embodiments, the flash copy operation is IBM FlashCopy® (Registered Trademark of International Business Machines Corporation). The persistent storage mapping component **192** maps the data blocks to the storage blocks. In some embodiments, a flash copy command specifies a source disk from which a disk image is generated and a target disk on which the disk image is stored. In response to the flash copy command, the storage virtualization engine and storage virtualization interface component return a timestamp indicating a creation time of the disk image to the disk image management console.

[0104] In various embodiments, incremental flash copy is used to generate a child disk image. In various embodiments, incremental flash copy refers to generating a disk image of a disk such that each data block of the disk image that is different from its parent disk image is stored the physical storage device(s) **50**, and any data block that is the same as its parent disk image is shared in the physical storage device(s) **50** as illustrated in FIGS. **5**B, **5**C and **5**D. Incremental flash copy generates a point-in-time copy. In some embodiments, an incremental flash copy command specifies the disk for which the child disk image is generated and its parent disk image. In response to the incremental flash copy command, the storage virtualization engine and storage virtualization interface component returns a timestamp indicating a creation time of the disk image to the disk image management console.

[0105] A flash copy is also used to retrieve a specified disk image from the storage device(s) **50** and store that disk image on a specified disk, in some embodiments, a virtual disk. The persistent storage mapping component is invoked to identify and retrieve the storage blocks that contain the data blocks of the specified disk image. If the specified disk image is a child disk image, the data blocks comprise the shared storage blocks from the ancestor disk image(s) and the different data blocks of the specified child disk image. In some embodiments, a flash copy command comprises a disk image name and a timestamp to specify the disk image to copy, and a target disk to which the disk image is copied.

[0106] In response to a user request, the disk image management console **184** issues at least one storage system command to the storage virtualization engine interface component **46**. The storage system commands comprise flash copy and incremental flash copy.

[0107] In response to receiving a flash copy command, the storage virtualization engine interface component **46** invokes the storage virtualization engine **48** to perform the flash copy operation. The storage virtualization engine **48** generates a disk image of the disk specified by the disk image name and timestamp to the target disk, and returns a timestamp indicating the time of creation of the disk image. In the storage virtualization engine **48**, the persistent storage mapping component **192** updates a mapping of the different and shared data blocks to storage blocks for the disk image.

[0108] In response to receiving an incremental flash copy command, the storage virtualization engine invokes the difference monitoring component **190** and the persistent storage mapping component **192**. The difference monitoring component **190** identifies each data block of the specified disk for which to generate a child disk image that is different from the data blocks of the specified parent disk image. The difference monitoring component **190** also identifies the data blocks of the specified disk for which to generate a child disk image that is the same as the data blocks of the specified parent disk image. The persistent storage mapping component **192** updates a mapping of the different and shared data blocks to storage blocks for the child disk image.

[0109] FIG. **7** depicts a flowchart of an embodiment of managing disk images for server provisioning. In step **230**, a disk image is generated. The disk image is stored in at least one persistent storage device. The disk image comprises at least one software application and is a root disk image.

[0110] In step **231**, an inheritance tree comprising a root node associated with the root disk image is created.

[0111] In step **232**, a new disk image of a disk is generated based on a previously generated disk image associated with a node of the inheritance tree. The new disk image is stored in the at least one persistent storage device. The new disk image comprises at least one software application of the previously generated disk image and at least one new software application. The new disk image shares at least one data block of the previously generated disk image in the at least one persistent storage device. At least one data block of the new disk image is different from the previously generated disk image.

[0112] In step **233**, a new node is added to the inheritance tree. The new node is associated with the new disk image. The new node is a child node of the node that is associated with the previously generated disk image.

[0113] In step **234**, at least one new software application is installed on a disk comprising a copy of one of the previously generated disk images.

[0114] Step **235** determines whether a user wants to generate another disk image. If so, step **235** proceeds to step **232**. If not, step **235** proceeds to step **236** and the flowchart exits.

[0115] FIG. **8** comprises FIGS. **8**A and **8**B which collectively depict a flowchart of an embodiment of managing disk images for server provisioning. In step **240**, the disk image management console presents an inheritance tree. In some embodiments, step **240** is omitted.

[0116] Step **242** determines whether there is a node corresponding to a desired base disk image in an inheritance tree. In some embodiments, a user performs step **242**.

[0117] In other embodiments, the disk image management console performs step **242**. The disk image management console receives a specified machine type and the desired topology of the application server software from the user. The desired topology specifies at least one software application. The disk image management console determines whether a desired base disk image is in the inheritance tree based on the machine type and specified software application(s) of the desired topology. The disk image management console identifies at least one candidate inheritance tree based on the machine type of the inheritance tree matching the specified machine type. In other embodiments a separate machine type is not received and the machine type is included in the name of the specified root software application; and the disk image management console identifies a candidate inheritance tree

based on the application stack name of the root node matching the name of the specified root software application.

[0118] The disk image management console traverses the nodes of the candidate inheritance tree to identify a node that is associated with a disk image comprising all specified software application(s) based on the application stack name of the nodes. For example, if the specified software applications are the "Windows 2000 server" and the "DB2 8.0 server", the disk image management console searches for a root node having an application stack name of "Windows 2000 server", and searches the child nodes of the root node for an application stack name of "DB2 8.0" server. In response to finding a root node having an application stack name of "Windows 2000 server" that has a child node having an application stack name of "DB2 8.0" server, the disk image management console determines that the candidate inheritance tree has a node corresponding to the desired base disk image. The child node with the application stack name of "DB2 8.0 server" is identified as corresponding to the desired base disk image.

[0119] In response to step **242** determining that a node corresponding to the desired base disk image is in an inheritance tree, in step **244**, the node corresponding to the base disk image is selected. In some embodiments, the user manually selects the node corresponding to the base disk image, in some embodiments using a command line interface and in other embodiments using a graphical user interface. In various embodiments, the disk image management console selects the child node determined to correspond to the desired base disk image of step **242**. In various embodiments, the name of the base disk image and associated timestamp are retrieved from the child node that is determined to correspond to the desired base disk image.

[0120] In step **246**, the base disk image is copied to a virtual disk. In various embodiments, the disk image management console issues a flash copy command with the name and timestamp of the base disk image, and a specified virtual disk, to the storage virtualization engine interface component. The storage virtualization interface component invokes the storage virtualization engine to copy the base disk image from the storage device(s) to the specified virtual disk. Alternately, a copy command other than flash copy is issued.

[0121] In step **248**, the disk image management console exposes the virtual disk with the new copy of the base disk image to the user. The virtual disk is made available to the user.

[0122] In step **250**, a new software application is installed on the new copy of the base disk image on the virtual disk. In various embodiments, the user installs the new software application. In other embodiments, the disk image management console, in response to the user, automatically installs the new software application.

[0123] In step **252**, a new disk image is generated by performing an incremental flash copy of the virtual disk with the new software application. In various embodiments, the new disk image has the same name as the base disk image and a different timestamp. In some embodiments, in response to a request from the user at the disk image management console, the disk image management console issues a command to perform an incremental flash copy of the virtual disk with the new software application with respect to its selected base disk image.

[0124] In step **254**, the tree topology module updates the inheritance tree based on the new disk image such that the node corresponding to the base disk image is a parent of a new node corresponding to the new disk image. The disk image management console invokes the tree topology module. The tree topology module adds a new node corresponding to the new disk image as a child disk image of the node corresponding to the selected base disk image in the inheritance tree. The new node comprises a name of the application stack, the name of the disk image, the timestamp indicating the time of the generation of the disk image by the incremental flash copy, and a pointer to the node in the inheritance tree corresponding to its parent disk image. In addition, the tree topology module updates the pointer(s) of the node corresponding to the base disk image by adding a pointer to the node corresponding to its new child disk image. The user typically provides the name of the application stack. In some embodiments, step **254** is automatically performed after step **252** is completed.

[0125] If step **242** determines that a node corresponding to the desired base disk image is not in an inheritance tree, the flowchart proceeds via Continuator A to step **258** of FIG. **8**B. In step **258**, the disk image management console determines whether there is a node corresponding to a similar disk image in the inheritance tree. In some embodiments, the user identifies a similar disk image. In other embodiments, the disk image management console identifies a similar disk image based on the specified software application(s) and machine type. The disk image management console determines whether an inheritance tree has a disk image corresponding to the specified root software application and machine type. If so, the disk image management console identifies a node of that inheritance tree corresponding to a disk image that contains the greatest number of the specified software applications as the node corresponding to a similar disk image. The similar disk image contains less than all of the specified software applications of the request.

[0126] In response to determining that there is a node corresponding to a similar disk image in an inheritance tree, in step **260**, the information describing the similar disk image is presented to the user. In some embodiments, the information is presented by highlighting a graphical image representing the node on a graphical user interface; in other embodiments, the information is presented by listing the software application(s) of its application stack, its disk image name and timestamp.

[0127] Step **262** determines whether the user wants to use the similar disk image as the base disk image. For example, the disk image management console may present a prompt asking if that user wants to use the similar disk image as the base disk image. If the user does not, step **262** proceeds to step **274**.

[0128] In response to the user affirmatively indicating using the similar disk image as the base disk image, in step **266**, the base disk image is copied to a virtual disk. The disk image inheritance management component retrieves the disk image name and timestamp of the base disk image, in this case the similar disk image, from its corresponding node, and issues a flash copy command to the storage virtualization interface component with the disk image name, timestamp, and a specified virtual disk.

[0129] In step **268**, the virtual disk with the new copy of the base disk image is exposed to the user.

[0130] In step **270**, the user uninstalls any undesired software application from the virtual disk. In some embodiments step **270** is omitted.

[0131] In step **272**, the user installs the desired software application on the virtual disk. In various embodiments,

desired software application is a new software application. In some embodiments, the desired software application is an upgrade to an existing software application. The flowchart proceeds via Continuator B to step **252** of FIG. **8**A.

[0132] In response to step **258** determining that there is not a node corresponding to a similar disk image in an inheritance tree, in step **274**, the disk image management console allows a user to select a base disk image from an inheritance tree. Step **276** determines whether a base disk image is selected. In response to selecting a base disk image, the disk image management component proceeds to step **266**.

[0133] In response to a user not selecting a base disk image in step **276**, in step **278**, the disk image management console determines whether the user wants to create a new inheritance tree. If not, in step **280**, the flowchart exits. If so, in step **282**, the disk image management console provides a virtual disk. The virtual disk has no software application.

[0134] In step **284**, the disk image management console causes the virtual disk to be exposed to the user. In step **286**, the user installs at least one software application on the virtual disk.

[0135] In step **288**, a new disk image is generated based on the virtual disk on at least one storage device. In various embodiments, the disk image management console issues a flash copy command to generate the new root disk image and store it on the storage device(s).

[0136] In step **290**, the tree topology module of the disk image management component creates a new inheritance tree comprising a root node corresponding to the new disk image. The new root node contains the name of the new disk image, the timestamp of the generation of the disk image and an application stack name. In various embodiments, the user provides the name of the disk image and the application stack name.

[0137] In an alternate embodiment, a similar disk image is not identified and steps **258**, **260** and **262** are omitted, and step **242** of FIG. **8**A proceeds to step **274** of FIG. **8**B.

[0138] An example of the generation of a new disk image based on an existing disk image will now be described. For example, suppose a user wants to create a new disk image by installing a DB2 8.0 server on an existing Windows 2000 server on a blade server. The user communicates with the disk image management console to specify that the desired machine type is a blade server and the desired root software application is a Windows 2000 server. In step **242**, the disk image management console invokes the tree topology module to determine whether there is a node corresponding to the desired base disk image, in this example, a root disk image comprising the Windows 2000 server that executes on a blade server. In response to determining that there is a root node corresponding to a disk image comprising a Windows 2000 server that executes on a blade server, in step **244**, the node corresponding to the desired base disk image, in this case the root disk image comprising the Windows 2000 server that executes on a blade server, is selected.

[0139] In step **246**, the base disk image is copied to a virtual disk. In step **248**, this virtual disk is exposed to the user as a Windows 2000 server.

[0140] In step **250**, the DB2 8.0 server is installed on the virtual disk. In this example, the user manually installs the DB2 8.0 server on the virtual disk comprising the Windows 2000 server that executes on a blade server. In response to the installation of the DB2 8.0 server, data blocks on the virtual disk are changed.

[0141] In step **252**, a new disk image is generated by performing an incremental flash copy of this virtual disk. New storage blocks are generated for the data blocks that are changed by the installation of the DB2 8.0 server. As for the unchanged data blocks, the virtual disk will use its parent's storage block(s) as shared data blocks.

[0142] In step **254**, the disk image management console invokes the tree topology module to update the inheritance tree. The tree topology module adds a new node corresponding to the new disk image as a node of the node corresponding to the base disk image. In some embodiments, the user, via the disk image management console, activates a graphical control that when activated causes the inheritance tree to be updated with a node corresponding to the child disk image. In other embodiments, the disk image management console receives a command from a user via the command line interface to update the inheritance tree.

[0143] FIG. **9** depicts a flowchart of an embodiment of provisioning a server. In step **292**, the disk image management console receives, from a user, a request to provision a server comprising a host name with disk image parameters. The disk image parameters comprise the name of at least one software application and a machine type, and in some embodiments, a host name and the storage size. The host name designates the server, which in various embodiments is an application server.

[0144] In step **294**, the disk image management console determines whether there is a node corresponding to a disk image matching the disk image parameters in an inheritance tree. The disk image management console invokes the tree topology module to make this determination. The tree topology module determines whether a node of an inheritance tree corresponds to a disk image for the specified machine type and comprising all the specified software application(s) as described above with respect to step **242** of FIG. **8**A. In some embodiments, the tree topology module also determines whether the storage size of the disk image matches the storage size of the request. If there is no node corresponding to a disk image matching the disk image parameters in an inheritance tree, in step **296**, the flowchart exits.

[0145] In response to the disk image management console determining, in step **294**, that there is a node corresponding to a disk image matching the disk image parameters in the inheritance tree, in step **298**, the data blocks of the disk image matching the disk image parameters are copied to a virtual disk. The disk image management console retrieves the disk image name and timestamp from the node corresponding to the matching disk image. The disk image management console issues a flash copy command with the retrieved disk image name and timestamp to copy the data blocks of that disk image from at least one storage device to a virtual disk.

[0146] In step **300**, the disk image management console maps the virtual disk with a host based on the host name. After mapping the virtual disk with the host, the host can be booted using the software on the virtual disk.

[0147] In an alternate embodiment, step **298** is omitted, and the disk image in the storage device is mapped to the host to provision the server software.

[0148] FIG. **10** depicts a flowchart of another embodiment of provisioning server. In various embodiments, FIG. **10** replaces step **296** of FIG. **9**.

[0149] In step **302**, the tree topology module determines whether there is a node in an inheritance tree corresponding to a disk image that is similar to the specified disk image param-

eters. A node is determined to correspond to a disk image that is similar to the specified disk image parameters as described above with reference to step **258** of FIG. **8**B. In response to determining that no node corresponds to a similar disk image, in step **304**, the flowchart exits. In response to determining that a node corresponds to a similar disk image, in step **306**, the data blocks of the similar disk image are copied to a virtual disk. The disk image management console retrieves the disk image name and timestamp of the similar disk image from the corresponding node in the inheritance tree and issues a flash copy command with that disk image name and timestamp. In step **308**, the virtual disk is mapped with a host based on the host name.

[0150] In various embodiments, a flash copy is used to generate and copy disk images. In other embodiments, a copy operation other than the point-in-time flash copy is used to generate a full disk image and to copy a disk image. In various embodiments, an incremental flash copy is used to generate a disk image which shares at least one data block with another disk image. In other embodiments, an incremental copy operation other than the point-in-time incremental flash copy is used to generate a disk image which shares at least one data block.

[0151] Various embodiments of the invention can take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment containing both hardware and software elements. In a preferred embodiment, the invention is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

[0152] Furthermore, various embodiments of the invention can take the form of a computer program product accessible from a computer usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer usable or computer readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0153] The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk—read only memory (CD-ROM), compact disk—read/write (CD-R/W) and digital video disk (DVD).

[0154] FIG. **11** depicts an illustrative storage system **320** which uses various embodiments of the present invention. The storage system **320** suitable for storing and/or executing program code will include at least one processor **322** coupled directly or indirectly to memory elements **324** through a system bus **326**. The memory elements **324** can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution.

[0155] Input/output or I/O devices **328** (including but not limited to, for example, a keyboard **330**, pointing device such as a mouse **332**, a display **334**, etc.) can be coupled to the system bus **326** either directly or through intervening I/O controllers. In other embodiments, I/O devices **328** are omitted.

[0156] Network adapters, such as a network interface (NI) **340**, may also be coupled to the system bus **326** to enable the storage system to become coupled to servers or data processing systems or remote printers or other storage devices through intervening private or public networks **342**. Modems, cable modem and Ethernet cards are just a few of the currently available types of network adapters. The network adapter may be coupled to the network via a network transmission line, for example twisted pair, coaxial cable or fiber optic cable, or a wireless interface that uses a wireless transmission medium. In addition, the software in which various embodiments are implemented may be accessible through the transmission medium, for example, from a server over the network.

[0157] The memory elements **324** store a storage virtualization engine interface component **46**, a storage virtualization engine **48** providing virtual disk(s) **354**, managed disk(s) **336** and a disk image management application **360**. The virtual disks **354** are stored in the managed disk(s) **336**. The disk image management application **360** comprises the disk image inheritance management component **42**, tree topology module **186** and one or more inheritance trees **44**. In various embodiments, the disk image inheritance management component **42** comprises the disk image management console **184** of FIG. **6** and tree topology module **186** of FIG. **6**. In some embodiments, the memory elements **304** also comprise an operating system **358**.

[0158] The operating system **358** may be implemented by any conventional operating system such as z/OS® (Registered Trademark of International Business Machines Corporation), MVS® (Registered Trademark of International Business Machines Corporation), OS/390® (Registered Trademark of International Business Machines Corporation), AIX® (Registered Trademark of International Business Machines Corporation), UNIX® (UNIX is a registered trademark of the Open Group in the United States and other countries), WINDOWS® (Registered Trademark of Microsoft Corporation), LINUX® (Registered trademark of Linus Torvalds), Solaris® (Registered trademark of Sun Microsystems Inc.) and HP-UX® (Registered trademark of Hewlett-Packard Development Company, L.P.).

[0159] The exemplary storage system **320** that is illustrated in FIG. **11** is not intended to limit the present invention. Other alternative hardware environments may be used without departing from the scope of the present invention.

[0160] Various embodiments of the present invention have the following advantages. In some embodiments, storage capacity is efficiently utilized. In various embodiments, the disk image inheritance technique greatly reduces storage consumption of persistent storage. Since there are typically many common data blocks among child and ancestor disk images, those data blocks will be shared. Hence, in various embodiments, a large number of application server disk images can be created and stored in the storage system. Therefore, using various embodiments, a user can construct a fast and on-demand application server provisioning service repository.

[0161] Another advantage of various embodiments is that the storage level management is independent from the host, in some embodiments an application server. Various embodiments of the present invention are implemented in the storage system, and therefore do not affect the upper layer operating

system that is executed by the host. Thus, various embodiments reduce the complexity of disk image management and improve the management performance.

[0162] Yet another advantage of some embodiments is the ease of maintenance and use. Using some embodiments, from the application server provisioning service point of view, performing disk image management at the storage system is easy to maintain and use.

[0163] The foregoing detailed description of various embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teachings. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended thereto.

What is claimed is:

1. A computer-implemented method comprising:

generating a disk image, said disk image being stored in at least one persistent storage device, said disk image comprising at least one software application, said disk image being a root disk image;

creating an inheritance tree comprising a root node associated with said root disk image;

generating a new disk image of a disk based on a previously generated disk image associated with a node of said inheritance tree, said new disk image being stored in said at least one persistent storage device, said new disk image comprising at least one software application of said previously generated disk image and at least one new software application, said new disk image sharing at least one data block of said previously generated disk image in said at least one persistent storage device, at least one data block of said new disk image being different from said previously generated disk image; and

adding a new node to said inheritance tree, said new node being associated with said new disk image, said new node being a child node of said node that is associated with said previously generated disk image.

2. The method of claim **1** further comprising, in response to a user, repeating said generating said new disk image and said adding said new node.

3. The method of claim **1** wherein said previously generated disk image comprises a plurality of software applications, and said new disk image comprises all of said plurality of said software applications of said previously generated disk image and said at least one new software application.

4. The method of claim **1** wherein said disk is a virtual disk.

5. The method of claim **4** wherein said at least one persistent storage device comprises at least one managed disk.

6. The method of claim **1** wherein said generating said disk image comprises performing a flash copy, and said generating said new disk image comprises performing an incremental flash copy.

7. The method of claim **2** further comprising:

graphically presenting said inheritance tree.

8. The method of claim **2** wherein said inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, further comprising:

selecting one of said nodes of said inheritance tree; and

mapping said disk image associated with said one of said nodes that is selected to a host.

9. The method of claim **2** wherein said inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, further comprising:

selecting one node of said plurality of nodes of said inheritance tree;

copying said disk image associated with said one node that is selected from said at least one persistent storage device to said disk; and

installing said at least one new software application on said disk.

10. The method of claim **2** wherein said inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, further comprising:

receiving a request to provision server software, said request specifying at least one software application and a host;

identifying one node of said nodes of said inheritance tree based on said at least one software application of said request;

copying said disk image corresponding to said one node that is identified to a virtual disk; and

mapping said virtual disk to said host.

11. The method of claim **10** wherein each node of said plurality of nodes comprises a disk image name, a timestamp, and an application stack name, and said selecting said one node of said plurality of nodes of said inheritance tree is also based on said application stack name; and said disk image that is copied is based on said disk image name and said timestamp corresponding to said one node that is identified.

12. The method of claim **2** wherein said inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, further comprising:

receiving a request to provision server software, said request specifying at least one software application;

identifying one node of said plurality of nodes of said inheritance tree based on said at least one software application of said request; and

mapping said disk image corresponding to said one node that is identified to a host.

13. A computer program product comprising a computer usable medium having computer usable program code for provisioning a server, said computer program product including:

computer usable program code for generating a disk image, said disk image being stored in at least one persistent storage device, said disk image comprising at least one software application, said disk image being a root disk image;

computer usable program code for creating an inheritance tree comprising a root node that is associated with said root disk image;

computer usable program code for generating a new disk image of a disk based on a previously generated disk image associated with a node of said inheritance tree, said new disk image being stored in said at least one persistent storage device, said new disk image comprising at least one software application of said previously generated disk image and at least one new software application, said new disk image sharing at least one data block of said previously generated disk image in said at least one persistent storage device, at least one data block of said new disk image being different from said previously generated disk image; and

computer usable program code for adding a new node to said inheritance tree, said new node being associated with said new disk image, said new node being a child node of said node associated with said previously generated disk image.

14. The computer program product of claim **13** wherein said computer usable program code for generating said disk image invokes a flash copy, and said computer usable program code for generating said new disk image invokes an incremental flash copy.

15. The computer program product of claim **13** further comprising:

computer usable program code for presenting said inheritance tree.

16. The computer program product of claim **13** further comprising:

computer usable program code for receiving a selection of a node of said inheritance tree; and

computer usable program code for mapping said disk image associated with said node that is selected to a host.

17. The computer program product of claim **13** wherein said inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, further comprising:

computer usable program code for receiving a request to provision server software, said request specifying at least one software application and a host;

computer usable program code for identifying one node of said nodes of said inheritance tree associated with a disk image comprising said at least one software application of said request;

computer usable program code for copying said disk image corresponding to said one node that is identified to a virtual disk; and

computer usable program code for mapping said virtual disk to said host.

18. The computer program product of claim **14** wherein said request specifies a plurality of software applications, further comprising:

computer usable program code for identifying one similar node of said nodes of said inheritance tree associated with a similar disk image comprising less than all of said software applications of said request: and

computer usable program code for copying said similar disk image to a virtual disk.

19. The computer program product of claim **13** wherein each node of said plurality of nodes comprises a disk image name, a timestamp, and an application stack name, and said computer usable program code for selecting said one node of said plurality of nodes of said inheritance tree is based on said application stack name; and said computer usable program code for copying said disk image copies said disk image based on said disk image name and said timestamp corresponding to said one node that is identified.

20. The computer program product of claim **13** wherein said inheritance tree comprises a plurality of nodes associated with a plurality of disk images, respectively, further comprising:

computer usable program code for receiving a request to provision server software, said request specifying at least one software application and a host;

computer usable program code for identifying one node of said plurality of nodes of said inheritance tree based on said at least one software application of said request; and

computer usable program code for mapping said disk image corresponding to said one node that is identified to said host.

21. A storage system comprising:

at least one processor;

at least one persistent storage device storing a plurality of disk images sharing at least one data block; and

a memory storing an inheritance tree comprising a plurality of nodes, each node being associated with a disk image of said plurality of disk images, said plurality of nodes having a hierarchical relationship based on at least one software application of said plurality of disk images;

said memory also storing instructions to be executed by said at least one processor, said instructions causing said at least one processor to:

generate a root disk image, said root disk image being stored in at least one persistent storage device, said root disk image comprising at least one software application;

create a new inheritance tree comprising a root node that is associated with said root disk image;

generate a new disk image of a disk based on one disk image of said plurality of disk images, said new disk image being stored in said at least one persistent storage device, said new disk image comprising at least one software application of said one disk image and at least one new software application, said new disk image sharing at least one data block of said one disk image in said at least one persistent storage device, at least one data block of said new disk image being different from said one disk image; and

add a new node to said existing inheritance tree, said new node being associated with said new disk image, said new node being a child node of said node associated with said one disk image.

22. The storage system of claim **21** wherein said instructions that cause said at least one processor to the generate said disk image invoke a flash copy, and said instructions that cause said at least one processor to generate said new disk image invoke an incremental flash copy.

23. The storage system of claim **21**, wherein said memory further comprises instructions causing said at least one processor to:

present said inheritance tree.

24. The storage system of claim **21** wherein said memory further comprises instructions causing said at least one processor to:

receive a selection of a node of said inheritance tree; and

map said disk image associated with said node that is selected to a server.

25. The storage system of claim **21** wherein said memory further comprises instructions causing said processor to:

select one node of said plurality of nodes of said inheritance tree;

copy said existing disk image associated with said one node that is selected from said at least one persistent storage device to said disk; and

install said at least one new software application on said disk.

26. The storage system of claim **21** wherein said memory further comprises instructions causing said at least one processor to:

receive a request to provision server software, said request specifying at least one software application;

identify one node of said nodes of said inheritance tree based on said at least one software application of said request;

copy said disk image corresponding to said one node that is identified to a virtual disk; and

map said virtual disk to a host.

27. The storage system of claim **26** wherein said each node comprises a disk image name, a timestamp, and an application stack name, and said one node of said plurality of nodes is identified based on said application stack name; and said disk image that is copied is selected based on said disk image name and said timestamp corresponding to said one node

28. The storage system of claim **21** wherein said memory further comprises instructions causing said processor to:

receive a request to provision a server, said request specifying at least one software application and a host;

identify one node of said plurality of nodes based on said at least one software application of said request; and

map said disk image corresponding to said one node to said host.

29. A computer-implemented method of provisioning a server using a storage system comprising:

generating, in the storage system, a disk image, said disk image comprising a plurality of data blocks, all of said plurality of data blocks of said disk image being stored in at least one persistent storage device, said disk image comprising at least one software application, said disk image being a root disk image, said disk image having a disk image name and a timestamp;

receiving, by the storage system, an application stack name of said root disk image;

creating, in the storage system, an inheritance tree comprising a root node that is associated with said root disk image, said root node comprising said disk image name, said timestamp and said application stack name of said root disk image;

generating, in the storage system, a new disk image of a disk based on a previously generated disk image associated with a node of said inheritance tree, said new disk image being stored in said at least one persistent storage device, said new disk image comprising each software application of said at least one software application of said previously generated disk image and at least one new software application, said new disk image sharing at least one data block of said previously generated disk image in said at least one persistent storage device, at least one data block of said new disk image being different from said previously generated disk image, said new disk image having a new disk image name and a new timestamp;

receiving, by the storage system, a new application stack name of said new disk image; and

adding, by the storage system, a new node to said inheritance tree, said new node comprising said new disk image name, said new timestamp and said new application stack name, said new node being a child node of said node associated with said previously generated disk image.

30. The method of claim **29** further comprising:

in response to a user, repeating said generating said new disk image, said receiving said new application stack name, and said adding said new node to said inheritance tree.

31. The method of claim **29** wherein said disk is a virtual disk and said at least one persistent storage device comprises at least one managed disk.

32. The method of claim **29** wherein said generating said disk image comprises performing a flash copy, and said generating a new disk image comprises performing an incremental flash copy.

33. The method of claim **29** further comprising:

selecting one node of said nodes of said inheritance tree; and

mapping an application server to a disk image corresponding to said one node that is selected.

34. A storage system comprising:

at least one processor;

at least one persistent storage device storing a plurality of disk images sharing at least one data block; and

a memory storing an inheritance tree comprising a plurality of nodes, each node being associated with a disk image of said plurality of disk images, a first node of said plurality of nodes being a root node, said plurality of nodes having a hierarchical relationship;

said memory also storing instructions to be executed by said at least one processor, said instructions causing said at least one processor to:

generate a root disk image by performing a flash copy, said root disk image being stored in said at least one persistent storage device, said root disk image comprising at least one software application;

create an inheritance tree comprising a root node that is associated with said root disk image;

generate, by performing an incremental flash copy, a new disk image of a disk based on one disk image of said plurality of disk images, said new disk image being stored in said at least one persistent storage device, said new disk image comprising at least one software application of said one disk image and at least one new software application, said new disk image sharing at least one data block of said one disk image in said at least one persistent storage device, at least one data block of said new disk image being different from said one disk image; and

add a new node to said inheritance tree, said new node being associated with said new disk image, said new node being a child node of said node associated with said one disk image.

35. The storage system of claim **34** wherein said memory further comprises one or more instructions that cause said at least one processor to:

receive a request to provision an application server, said request specifying at least one specified software application and said application server;

identify a particular node of said nodes of said inheritance tree based on said at least one software application of said request;

copy a disk image associated with said particular node to a virtual disk; and

map said virtual disk to said application server.

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